BRITISH SOCIETY
FOR THE
STUDY OF ORTHODONTICS

1968/9

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HEADQUARTERS

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Barrie, W. J. McK.
Buchan, A.
Erskine, R. B.
Gibson, A. C. L.
Hargreaves, J. A.
Haynes, S.
Hopkin, G. B.
Logan, W. Russell
Miller, Miss M. N.
Woods, A. R. H.
Elderslie (Johnstone)
Hughes, F. J.
Elgin
Lawrie, D. A.
Fife
Clark, W. J.
Glasgow
Campbell, J.
Cockburn, A.
Houston, J. G.
MacCallum, W. A.
Thomson, Mrs. C. M.
Webster, Miss E. M.
Grangemouth
Stevenson, Wm.
Inverness
Ridley, Miss D. R.
Kirkcaldy
Mears, Miss R.
Paisley
McKechnie, R.
Stirling
McGonigal, F.

V. Ireland

Bangor
Dallas, H. A.
Belfast
Adams, C. P.
Bonnar, Miss E. M.
Hobson, G. S.
McCartney, T. I.
Richardson, A.
Richardson, Mrs. M. E.
Taylor, Miss B.
Cork
Brown, K. H.
Buckley, L. A.
Hegarty, Prof. M.
O'Connor, P. J.
Dublin
Clinch, L. M.
Dockrell, R. B.
Finn, S. D.
Fitzgerald, G. M.
Flood, N.
Greene, E.
Keith, J. E.
Kennedy, G. F.
Morris, V. B.

VI. Overseas Members

Australia

Adamson, Sir K. T.
Bowden, B. D.
Cox, N. J.
Crisp, B.C.
Gerraty, B. J.
Heath, J. R.
Lewis, P.
McDonald, J. D. H.
Norton, R. Y.
Nugent, M. A. C.
Reading, J. F.
Rogers, P. J.
Spring, D. F.
Taylor, A. Thornton
Tippett, I. D.
Watson, D. C.
Wenck, R. D.

Bermuda

McAnuff, R. M.

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Carpenter, I. P.
Copeland, G. P.
Croll, R. O.
Eastwood, A. W.
Franklin, G.
Fransblow, P.

Hackie, T. J.
Mulligan, W. O.
Oliver, H. T.
Yip, A. S. G.

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Gonzalez, R.

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Démogé, P. H.
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O'Meyer, R. X.
Schouker-Jolly, M.

Germany
Lervy, Major W. K.
Paton, Miss D. A.
Smart, Major R. A.

Greece
Bakatselos, S.
Tsaltas, G. K.

Hong Kong
Mak, K. L.
Tsang, Y. S.

India
Ghosh, A. S.
Patel, V. B.

Italy
Magni, F.

Jamaica
Lyn, M. R.

Malaysia
Chan, B. K.
Cheah, C. K.
Choo, S. B.
Lee Chin Kung
Leong, C. T.
Lye Thim Loke, Mrs.
Sundararaj, Mrs. S.
Tam, M. F.

Malta
Demajo, A.
Manara, G.

New Zealand
Ashby, J. W.
Bell, W. P. L.
Cook, C. C.
Gilbert, G. H.
Harkness, E. M.
Lang, E. T.
Valentine, H. B.
Willis, L. E.

Norway
Aamodt, A. C.
Engh, Olav
Johannesen, Børge
Krogstad, Olav, Jun.
Selmer-Olsen, Prof. R.

Rhodesia
Robson, F. F.

Singapore
Onn Lee Chee
Choo, T. C.
Lye, T. L., Mrs.

S. Africa
Braude, B.
De Muelenaere, J. J. G. G.
De Villiers, J. F.
Fainsinger, B. E.
Melville, R. G.
Miller, B.
Mizrahi, E.
Oosthuizen, L.

S. America
Abensur, J. (Peru)
Brears, O. B. (Ecuador)

Sweden
Ahlgren, J.
Granerus, R.
Granse, K. A.
Ljungdahl, L.
Lundström, Prof. A.
Pihl, Miss E. M. K.
Tegner, G.
Volmer Lind, H. C.

Switzerland
Hotz, Prof. R.

U.S.A.
Bell, L. A.
Blausten, S.
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Goldstein, M. C.
Gosman, S. D.
Gottlieb, A. W.
Grossman, R. C.
Jann, H. W.
Moss, G. W.
Panzer, Milton
Pinsker, L. J.
Sachs, N. J.
Schleimer, M.

AESTHETICS AND ORTHODONTICS

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WHEN I first contemplated addressing this Society on beauty I had qualms about the suitability of the subject. I then thought of ' Aesthetics ' as a title, but immediately realized I did not really know what it meant. On consulting *Webster's International Dictionary* I found ' Aesthetics . . . the Science of the Beautiful in Nature and Art '. Splendid! A scientific subject for a scientific society.

The idea of this investigation was really started in the early days of the National Health Service when the Dental Estimates Board tried to differentiate between orthodontics necessary for health and orthodontics as a beauty treatment. I was talking with an orthodontist of international fame when suddenly with a characteristic chuckle he exclaimed, If we had our teeth in our boots nobody would bother about orthodontics . . . '

This conflict of aims and objects had occurred earlier in Berlin. In 1923 Simon wrote, ' It is well known that many patients, perhaps the majority, apply for the correction of their dental anomalies for none other than cosmetic reasons and it would be a mistake to regard this notion or attitude as valueless '. He went on to argue that ' If the end sought were only cosmetic, our diagnosis would need no other basis '. He deplores this as it would lead to the orthodontist ridding himself of the concept of the normal to become an artist. The only objection he puts forward to this is to point out that art forms are not subject to measurement. He finished a 48-page discussion on the concept of the normal with these words, in italics: ' the Norm is, nevertheless a necessary fiction '. Begg, in 1965, finishing a discussion on ' Diagnosis and Assessment of Treatment Requirements ' wrote, ' Orthodontic treatment is presently very far from being an exact science. It is largely an empirical art '.

I shall try to discuss the subject ' Aesthetics and Orthodontics ' from as many viewpoints as possible with the result that the various aspects may not relate to one another but only to the central theme, thereby making the discourse somewhat disjointed.

THE PUBLIC DEMAND FOR ORTHODONTIC TREATMENT

There is no doubt that members of the general public, in so far as they bother about their teeth, want to have them what they call ' straight '. This demand has probably increased with the advent of television which has meant that each day all sorts and conditions of people who may have distinguished themselves by athletic feats,

Fig. 1.—Acknowledged beauty with Class II, division 1 incisor relationship. (*Reproduced from cover of* ' *Vogue* ' (1968), *No.* 3, 2000, **125**.)

by making public speeches, or by being subjected to some accident of fate have suddenly had their faces, and so their mouths and teeth, exhibited to millions of people at many times normal size. The public does not know much about orthodontic procedures. Two or three years ago at the semi-final stage of the ' Miss World ' competition, three of the twelve girls had quite definite Class II, division 1 malocclusions. *Fig.* 1 appeared on the cover of *Vogue* magazine. The lady

Presidential Address delivered at the meeting held on 14 October, 1968.

appears to me to be quite severely Class II, division 1, but *Vogue*, a leading authority on modern female beauty and so a most considerable influence on public taste, considers her beautiful.

Recently a girl who had won several beauty competitions consulted me. Her mouth is shown

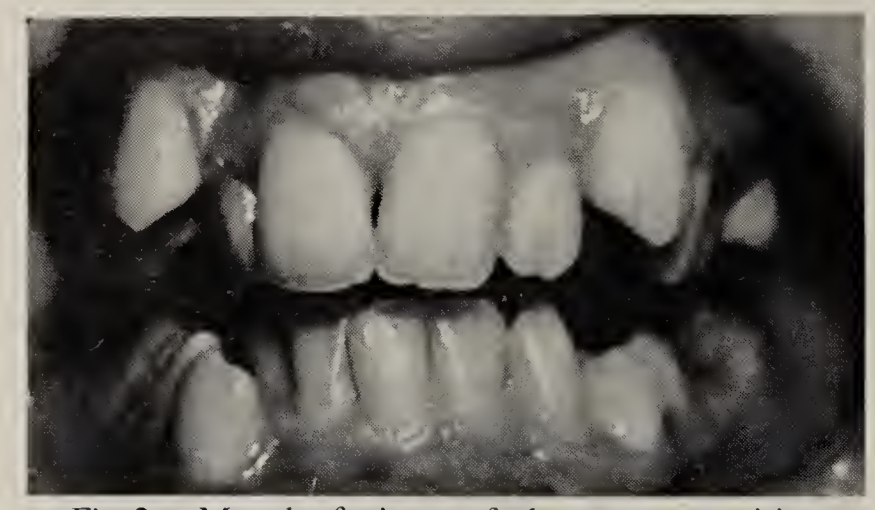


Fig. 2.—Mouth of winner of a beauty competition.

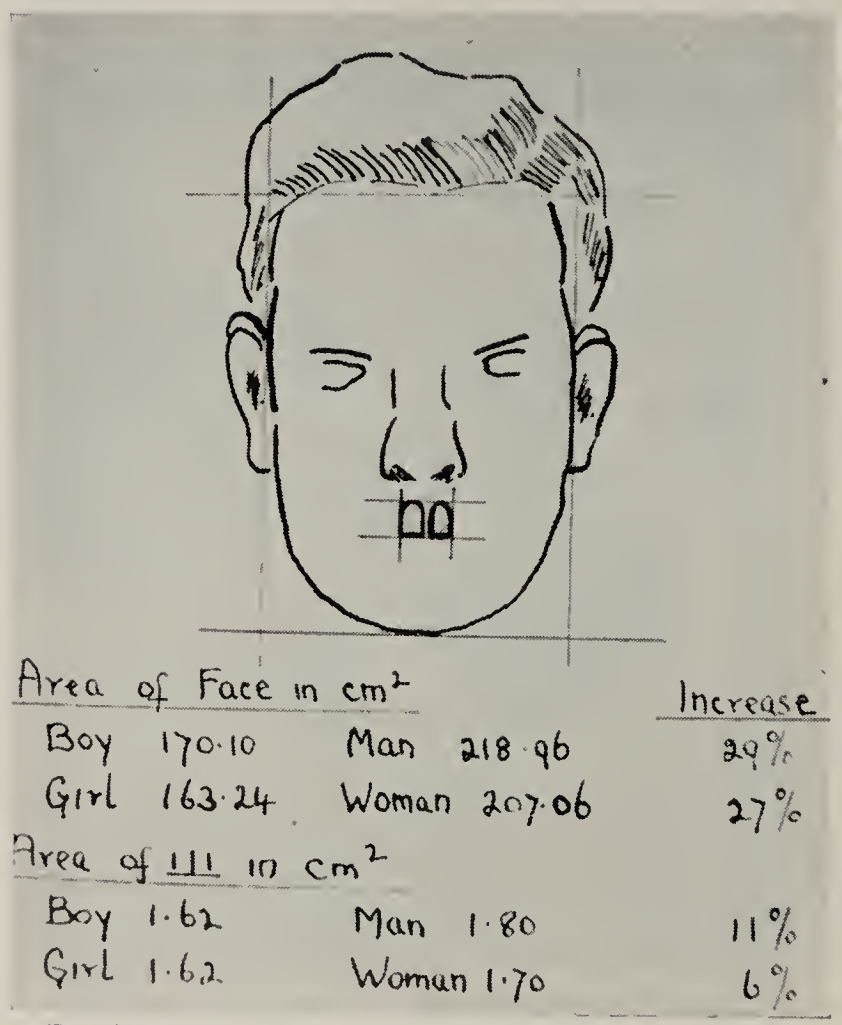


Fig. 3.—Comparison in child and adult of area of face and area of 1|1.

in *Fig*. 2. One may well imagine that her other attributes were considerable! She would not have fared so well at a dog show where judges are more knowledgeable about teeth.

In the deciduous dentition even severe malocclusion is usually not apparent to the parent. The abnormal overjet in a bad Class II, division 1 malocclusion is largely masked at this stage, as the anterior teeth are relatively so much smaller than the enveloping lips. It is only when the upper permanent centrals burst through the gums and the lips, often accompanied by a large diastema, that even the fondest mother begins to have doubts that all is not well with her darling offspring. This is the time of maximum demand by the public for orthodontic advice. The permanent teeth with their full adult width have suddenly taken their place in an immature face. In Class I this may be all that is apparently wrong. In Class II, division 1, however, where there has been an abnormal overjet in the deciduous dentition, it will now be greatly exaggerated with probably a full-scale lip trap.

In *Fig*. 3 I have made a comparison between the area occupied by 1|1 plus the diastema, with the area of the face, in the child at about $8\frac{1}{2}$ years, and in the adult. The face for this exercise was the anatomical face plus the frontal regions up to the hairline. (Characters with horizontal components to their faces were excluded.) The percentage increase in the size of the face was greater than that of the teeth. The toothy

A B

Fig. 4.—Profiles of King Edward VI. A, As a child. B, As an adult.

appearance at $8\frac{1}{2}$ years, therefore, is relieved spontaneously as the face grows larger and wider to fit the teeth.

Another relieving factor is the change in profile. With growth to maturity the dentition recedes into the face as the hard-tissue profile becomes less convex and the nose, lips, and chin develop. Serial profile records of individuals are difficult to find, but *Fig*. 4A, B shows how King Edward VI's dental area receded relative to his forehead and chin, although his nose did not fulfil its early promise.

DEFINITION OF BEAUTY

In a discussion on beauty it is as well to start with some idea as to its nature. Here I lean heavily on Newton (1950) who says, 'Much has been written in an effort to define beauty, which is not scientific. Statements such as that which

declares an object beautiful because it is like a rose, without attempting to state just why a rose is beautiful, are not helpful. Much has been written mixing Beauty with Truth and Beauty with Goodness, which does not advance our understanding.'

Margaret Wolfe Hungerford, about a hundred years ago, wrote, ' Beauty is in the eye of the

Fig. 5.—Leaf formations.

beholder ', and the more I study the subject the more I think this is the truth, the whole truth, and there is nothing more to be said, but as I cannot decently finish my Presidential Address here I shall cast around to demonstrate the application of this dictum.

Beauty in nature is the product of the mathematical behaviour of nature which in turn is a product of function. Beauty in art is a product of man's love of the mathematics of nature, based on his intuitive understanding of it. The idea I wish to develop is that there is mathematical order in nature, but most of it is too complicated to apprehend except intuitively.

Nature is functional and this functional behaviour can be expressed mathematically. The law of minimal containing areas is represented by the circle and demonstrated in leaf formations (*Fig.* 5). The nasturtium is almost round, the lupin deeply indentated, but still relatively simple mathematically; the buttercup is more complicated and the brocolli still more. All these forms can, however, be expressed mathematically. The *Nautilus* sea-shell and the Ram's horn snail shell follow a logarithmic spiral (*Fig.* 6) (Ghyka, 1952). The geometrical progression 1, 2, 4, 8, 16, 32, etc., if depicted by lines drawn at a constant angle to one another, produces the spiral form. The human eye can assess a straight line, a true circle, a horizontal, a vertical, a right angle, half a right angle and, by experience, build up an intuition which can apprehend much more complicated forms beyond present mathematical bounds.

I shall now try to trace civilized man's attempts over the past 2000 years to snare beauty in the meshes of mathematics.

The ' Golden Section '

This Divine Proportion originated in the Pythagorean theory of chosen numbers and was taken up by Plato as a mathematical relationship expressing universal harmony and so an ideal measure governing the relationship of the elements of the human body. It is derived from the Fibonacci series table 1, 2, 3, 5, 8, 13, 21 and

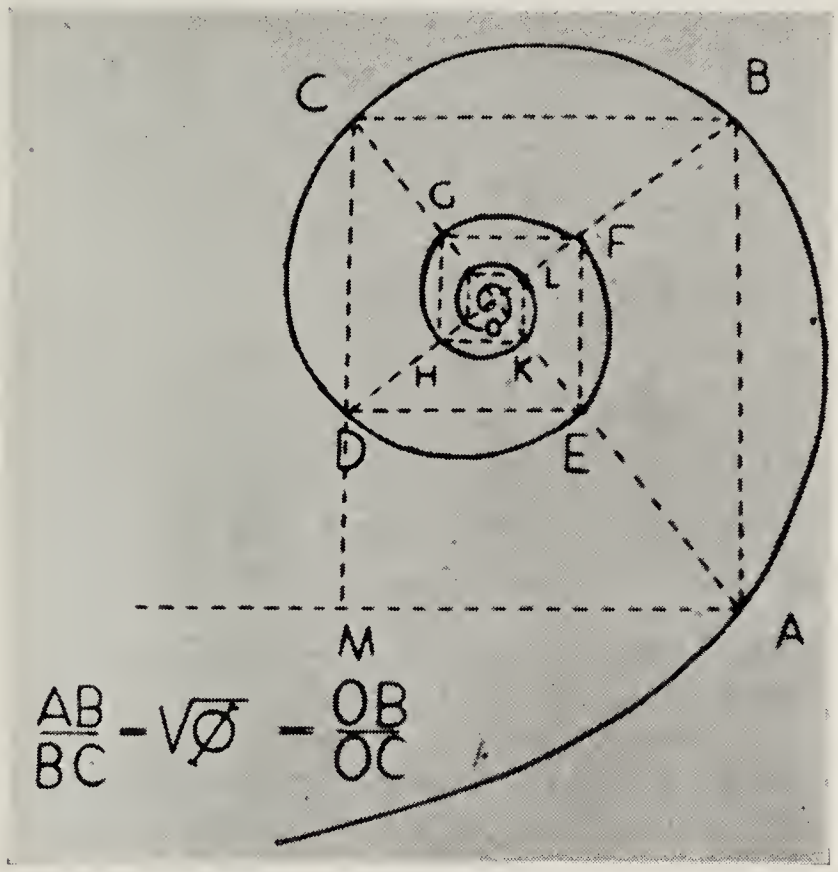


Fig. 6.—Shell structure.

expressed by $\frac{\sqrt{5}+1}{2}$ or $\frac{1}{1{\cdot}618}$ or roughly $\frac{5}{8}$. A drawing by Leonardo da Vinci of the head of Isabella d'Este shows lines dividing up the face into Golden Sections. Pictures, buildings, vases, etc., which conform to the ' Golden Section ' tend to be satisfactory and to look right. The element of $\sqrt{5}$ is important aesthetically as being present in many natural forms such as flowers, shells, and snowflakes.

Dürer in the early sixteenth century, following Leonardo's ideas, tried to find the normal relationship of the size of the body parts. He started with Vitruvius' canons of absolute beauty which stated that the length of the head was $\frac{1}{8}$ of the total height and that the face was $\frac{1}{10}$. The face he divided into 3 equal parts: the brow, the nose, and the rest (Panofssky, 1948).

In order that his system should include all individuals regarded as normal he was obliged to increase his types so that in 1528 his book contains figures whose heads were not only $\frac{1}{8}$ but $\frac{1}{7}$, $\frac{1}{9}$, and $\frac{1}{10}$ of the total height.

Brodie, 1946

Coming now to teeth and modern times, Brodie (1946), relates how J. Leon Williams sought to establish correlations between the forms of the teeth, the face, and the cranium.

Artificial teeth which were shaped on the basis of certain facial and cranial measurements were sold to the profession. Williams ultimately reversed his earlier contentions and concluded that no such correlations existed. Brodie writes, ' My entire plea is for an abandonment of the norm concept. It is time that we ceased to compare each individual we treat, with some pattern that has been arrived at either by an inner sense of porportions, or by the careful compilation and averaging of large series of measurements of different individuals.... But if we abandon these criteria what do we have left to guide us? The answer is: the very individual we are treating.'

Ricketts, 1957

Ricketts (1957) gave a complete formula for achieving aesthetic harmony. The lower central incisor is the key. Once the occlusal plane is established a line joining point A and pogonion is erected, with the lower incisor placed at an angle of 22° to this, with the tip 1 mm. forward. The upper central incisor is placed at an angle of 130° to the lower incisor and the other teeth in conformity. The author says, ' A question may be asked regarding functional balance without concomitant balance of the musculature. Again it is the author's opinion that the orthodontist should recognize such conditions and employ orthopaedic measures for muscle correction to permit stability of the case. Tongue and lip exercises have proven of value.... Neither poor muscle balance, habits, nor even facial type should be a definite obstacle toward attainment of the ideal '. This seems to me to assume an understanding of and control over the soft tissues which we do not have.

Burstone, 1958

Burstone (1958) in the Herron Study from 100 normal faces selected by artists, devised a mean grill of soft-tissue profile features and an average morphology. I quote his conclusion: ' The soft-tissue veneer covering the teeth and bones varies so greatly that study of the dento-skeletal pattern may be inadequate in evaluating facial disharmony '.

In 1967 he published carefully made measurements of the lip and interlabial space, and also showed that in some cases the lips have a position independent of the teeth. In his final conclusions he states, ' It has been suggested that one of the objectives of orthodontic treatment should be to minimize the amount of lip contraction from the relaxed to the closed position '. ' Lip posture should be considered an important element, if not the most important element, in determining a stable position of the incisors.'

Ballard, 1967

Ballard in his 1967 Northcroft Memorial Lecture related the lip position to the occlusal plane. He showed most factually how malrelationships of labial segments should and should not be treated to remain stable within their soft-tissue environment. His method seemed thoroughly practical, but beyond the scope of many practitioners. He said in discussion, however, that he was not so sure that for day-to-day practice the lateral skull radiograph was necessary. He believed that if one began to look at the habitual posture of the lower lip and relate it to the occlusal plane, this would be sufficient to determine the prognosis. So here we are back to square one, apprehending Beauty by Inspired Intuition having traced the attempts at Mathematisation from Leonardo to Ballard.

REQUIREMENTS OF ORTHODONTIC TREATMENT

Aesthetics is the most important consideration. After all it is for appearance that the patient has sought advice—the child never complains that he cannot eat. One knows from general dental practice that cheek teeth do not have to be in anything like normal number, alinement, or occlusion to give satisfaction, and this is born out by Professor Liddelow's film on chewing (Liddelow, 1964). The upper 6 front teeth should, therefore, be arranged in good alinement and the lower front teeth in acceptable alinement—satisfying full face aesthetic considerations. The overjet should be normal and the overbite acceptable to satisfy considerations of the profile, and the whole must be stable within the soft-tissue environment since this tends to have the last word in tooth positioning. The second requirement is the elimination of potential parodontal conditions and third molar impactions. The third requirement is function.

Hellman, 1939

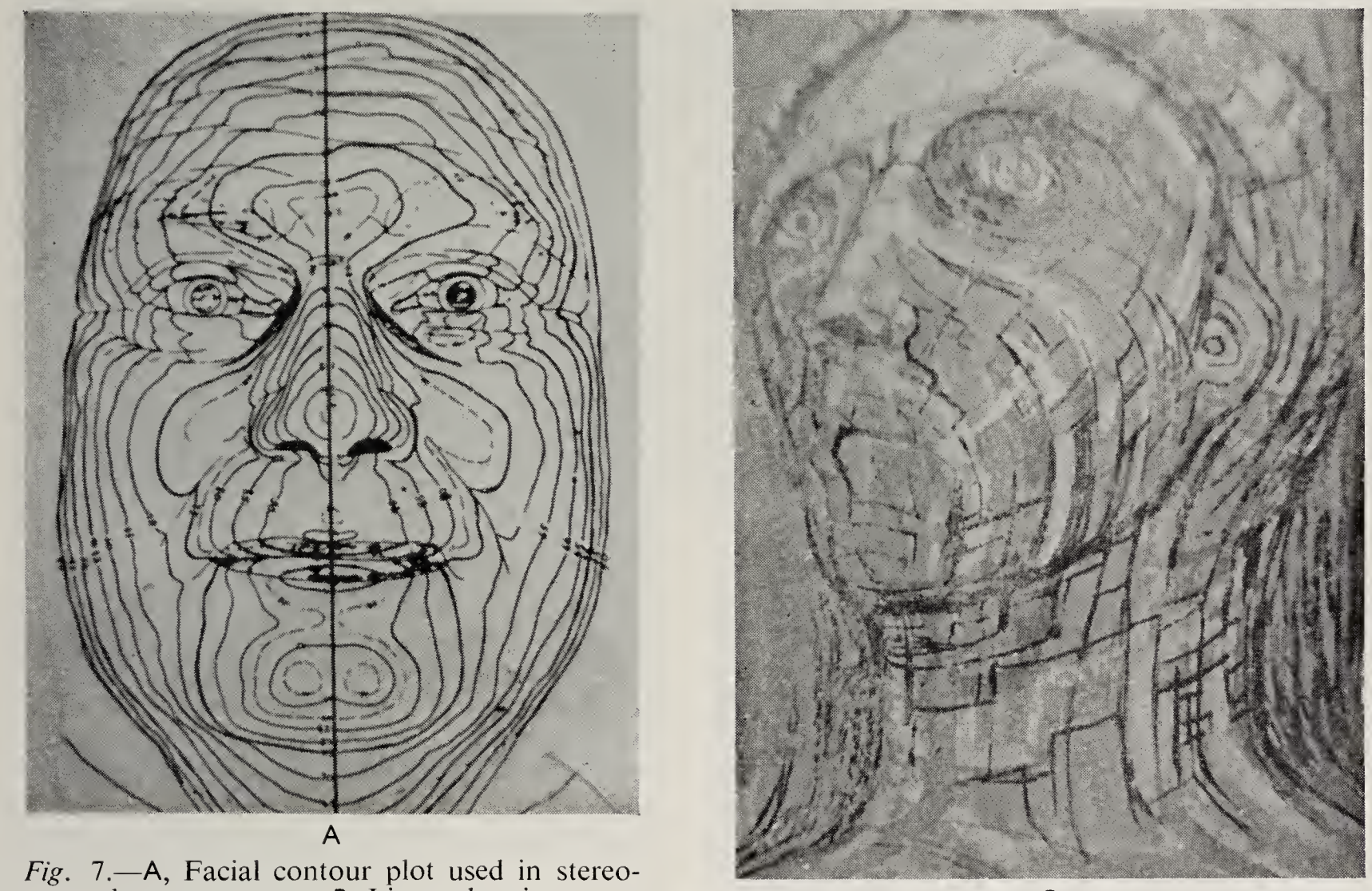
In 1939 Hellman published a study entitled ' Some Facial Features and their Orthodontic Implication ', which underlines vital aesthetic considerations. He studied 62 individuals each with 32 teeth in normal occlusion. On each individual he made 19 skull measurements in three dimensions and from these made an average. He then made a second category indicating the closest range of variability in the largest number of dimensions and called this the Normal Range of Variation. He then measured Class II, division 1 and Class III cases and noted the dimensions which were predominantly greater or less than the normal range. He noted the features which varied most often one way only.

Faces with Class II, division 1 malocclusion had the maxilla predominantly greater in height than normal (nasion to alveolar margin) and the mandible less in all dimensions. Faces with Class III malocclusion had abnormally long faces (total height) associated with open bite

(dental height). The upper face was retruded (auriculo-prosthion) and the lower face protruded (auriculo-infradentale and auriculo-menton).

All these dimensional tendencies are out of the sphere of influence of the orthodontist and therefore have to be accepted. It would seem logical, then, to do what Dürer did in 1528 when he hypothecated variations on Vitruvius' canons of absolute beauty and to recognize a normal Class II, division 1 face and a normal Class III face. I do not mean, of course, that these cases should not be treated; but the variation of normality imposed on the individual should be recognized. Even in Hellman's normal occlusion cases the individuals only scored 12 out of 19 normal measurements.

Lord David Cecil (1967) in a discussion on beauty wrote that sometimes there occurs a woman whose beauty is exceptional, rising above sex to become a symbol of the pure, essential idea of beauty. He relates the story of Lady Brownlow who on entering a ballroom in Dublin stopped the band spontaneously, so dazzled were the players by her beauty. One wonders whether she would have scored 19 out of 19 on Hellman's measurements.



A B

Fig. 7.—A, Facial contour plot used in stereophotogrammetry. B, Linear drawing.

Measurement of Soft Tissue by Stereophotogrammetry

Burke and Beard, in 1967, described a method of measuring the soft tissues in either two or three dimensions using a stereocamera and having the head fixed in a craniostat. The author stated, ' It is now hoped that this method can be used to obtain serial data on facial growth '. It is, obviously an important new technique in the study of aesthetics and can precisely estimate conditions of symmetry. It is interesting to compare the contour plot, produced in stereophotogrammetry with the linear drawing by Henry Moore (*Fig.* 7A, B).

Mr. Moore (personal communication) devised this method of directional contours to give the planes, as chiaroscuro is not very satisfactory in lithography limited to 2 or 3 colours.

A recent Tokyo stereophotogrammetry study (Haga, Ukiya, Koshihara, and Ota, 1964) showed that:—

1. The volume of the buccal regions is greater in the female than in the male.
2. Asymmetry increases with age and is related to dental disease.
3. The median line deviates to the right or left, but is usually at right angles to the line of the mouth.

Asymmetry

At first sight the child in *Fig.* 8 appears quite normal, but more careful inspection shows the left mandible to be greater than the right. This is demonstrated more clearly by making composite faces of two right halves and two left. Here is

only a mild example, for many of us, even those regarded as reasonably good looking, are very much worse. Why, then, are these defects not more noticeable?

Lhôte has, I think, the answer but stated in reverse. He says that symmetry and movement are contradictory elements. In the picture by El Greco shown in *Fig.* 9, St. Joseph's head is leaning to the left and looks quite normal. But in order to give this effect of normality, the artist has had to distort. He explains: ' The line joining the superciliary arches instead of making a right angle with that of the nose, falls in the direction of the inclination of the head. If you take a tracing of each half of the face distorted in this way, and placing each half on a median axis compose a symmetrical face with each one, the faces so produced will appear either too wide or too narrow. If you place it obliquely it will lack expressiveness; for symmetry and movement are contradictory elements.'

Fig. 9.—Symmetry and movement.

How do we then pass largely undetected with this very prevalent deformity of asymmetry? The reason is that we are almost never seen in absolute full face, motionless, with our Frankfurt planes horizontal. A little survey I carried out at the National Portrait Gallery seems to confirm this. Of 783 portraits examined only 42 (or 5 per cent) were full face. This, I think, is because others hardly ever see us in absolute full face and the artist is expected to produce a ' likeness '. Also, the artist realizes that full face is revealing of asymmetry and that few of us are sufficiently beautiful to bear such hard analysis. You would probably agree that the girl shown in *Fig.* 10A has quite good looking teeth. But notice that her head is turned a few degrees to the right. In *Fig.* 10B it is turned back through those few degrees and is seen in true full face. Immediately the large shift of the midline is obvious.

Fig. 8.—Mild asymmetry. A, Normal view. B, Right halves. C, Left halves.

Facial Changes due to Growth (Subtelny, 1959)

Subtelny (1959), in a study of profile changes in the hard and soft tissues, showed how the hard-tissue profile becomes less convex and the soft-tissue profile more convex (*Fig.* 11). Between the ages of 8 and 18 years the total profile angle (soft tissue) becomes more acute by 5° whereas the skeletal profile angle (hard tissue) becomes less acute by 6°. The chin developing earlier in girls develops a maximum prognathism at 13 years which is less at 18 years. The chin in boys continues to increase until 18 years. The nose grows steadily from 1 to 18 years and shows a greater forward increase than any other soft tissue of the face. It achieves greater length in boys than in girls. The labial alveolar plates and central incisors tend to recede relative to the facial plane.

A B

Fig. 10.—A, Midline—head slightly rotated. B, Midline—full face.

Soft-tissue increase is least at nasion, more at pogonion, more still at point A and even more at the vermilion of the lips.

Acceptable Irregularities of the Teeth

We have already learned from Newton that ' beauty in art is a product of man's love of the mathematics of nature ', and that the more advanced and therefore more interesting forms can only be appreciated intuitively. A second condition of beauty states that ' intuition must at times be baffled or it will become bored '. The contrast provided by subtle irregularities can relieve this boredom and is in the difference between a portrait by Goya and the face on the lid of a milk chocolate box. Conventional incisor symmetry is provided by 4321 1234, but 421 124 (*Fig.* 12A), 431 134 (*Fig.* 12B), or even 32 123 (*Fig.* 12C, D) are equally symmetrical and can be quite acceptable or even more exciting and interesting, depending on how one's aesthetic intuition has developed.

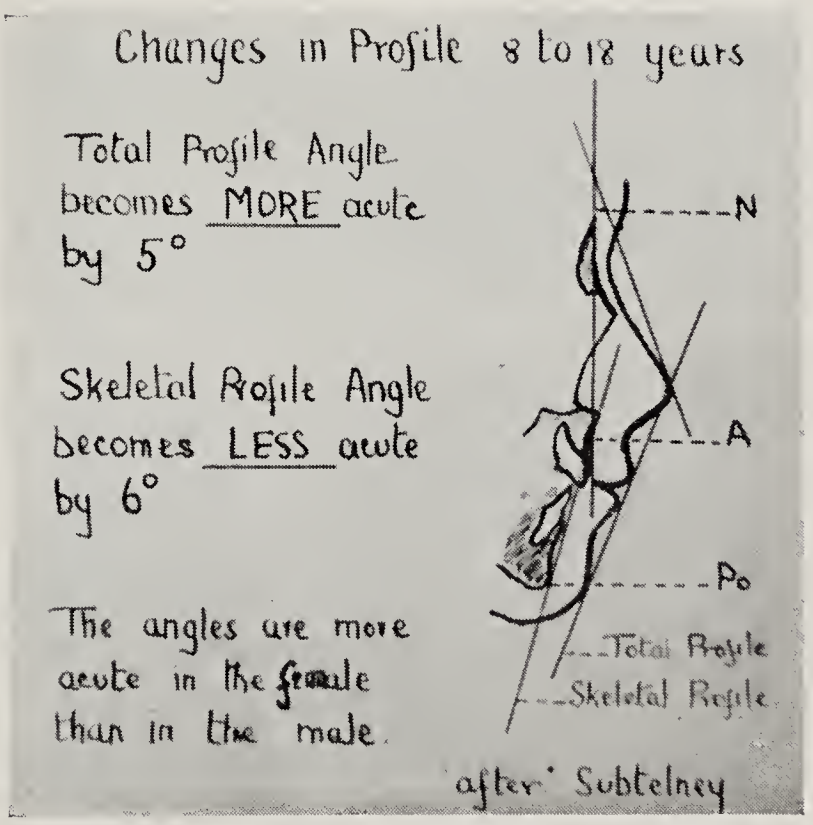

Changes in Profile 8 to 18 years
Total Profile Angle becomes MORE acute by 5°
Skeletal Profile Angle becomes LESS acute by 6°
The angles are more acute in the female than in the male.
N
A
Po
Total Profile
Skeletal Profile
after Subtelney

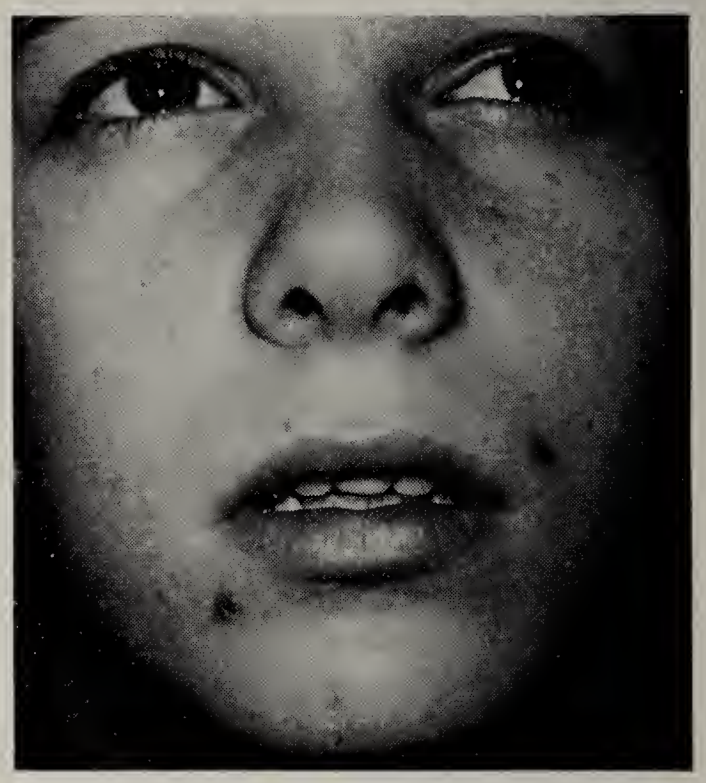
Fig. 11.—Normal changes in profile.

The upper lateral may be congenitally missing or unacceptably small and ugly. The small lateral is not only too short and too narrow, but also too thin buccolingually and so appears to be instanding. This may be relieved by extraction and space closure or by crowning (*Fig.* 12E). The case illustrated in *Fig.* 12F was generally considered acceptable. The upper canine is rarely missing, but may be the tooth of choice for extraction when it is grossly misplaced or of poor morphology. Providing that the palatal cusp of the first premolar is hidden by the lateral the buccal cusp looks extremely like a canine.

A

B

C



D

E

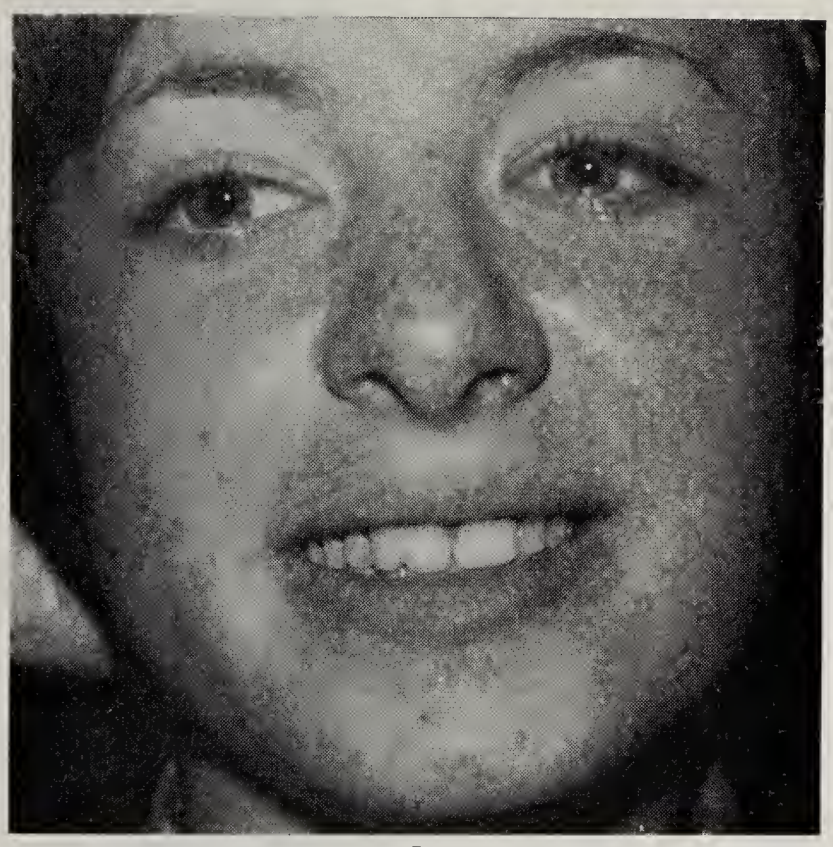
F

Fig. 12.—A, 421 124. B, 431 134. C, 32 123. D, 32 123. E, ' Peg ' laterals.
F, Acceptable small laterals.

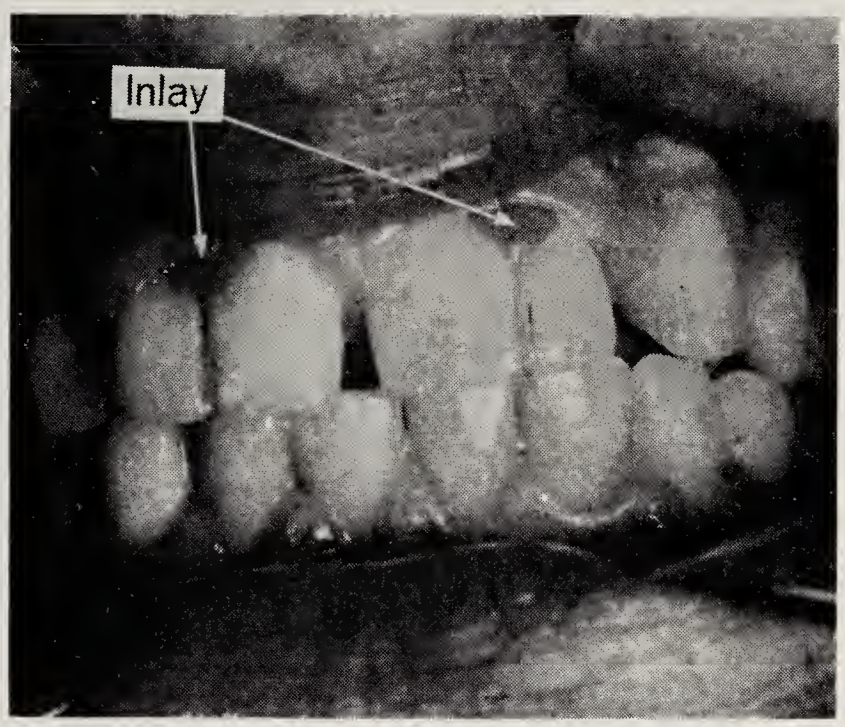
I am indebted to Mr. J. H. Gardiner for allowing me to publish *Fig.* 13A which shows a Negro with three centrals; the middle one is artificial, filling a large median diastema. The patient shown in *Fig.* 13B, C, has central incisors 13·5 the position of the teeth which are considered attractive, with the lower lip just lingual to the upper centrals at rest. I did not know her until she was grown up, but I think I should have wanted to treat her.

A

B



C



D

Fig. 13.—A, Three centrals. B, Large centrals $\frac{421\ 124}{}$. C, Large centrals $\frac{421\ 124}{}$. D, Large centrals with cosmetic inlays.

and 13 mm. wide, which are quite acceptable to the girl now she is grown up. *Fig.* 13D shows another approach to the same problem, with pink acrylic inlays and vertical lines. This is true cosmetic orthodontics. This case was kindly lent by Professor G. E. M. Hallett.

I am not averse to a little cheating with the grindstone at the end of treatment, as shown in *Fig.* 14A, B. On the other hand, when I wanted to shorten the centrals of the girl in *Fig.* 14C, her mother would have none of it, telling me that her daughter's teeth would lose their character if altered. The lady shown in *Fig.* 14D is very good looking, and there has never in her life been any question of treatment. The lower lip lies on the tips of the upper centrals at rest. In *Fig.* 14E, there has never been any regret about

The mother of the child in *Fig.* 14F said she thought the teeth looked ' cute ' and at first did not want treatment. I wonder whether I was right in changing her mind.

In Yorkshire we say, ' There's nowt as queer as folk ', which freely translated means ' normal individuals vary widely in their behaviour and ideas, and possession of a Diploma in Orthodontics and a spot welder is not sufficient qualification for laying down the law about the appearance of other people's children '.

Limitations to Aesthetics imposed by the Soft Tissues

There are limitations to aesthetics imposed by extremes of the soft-tissue covering which may be inadequate or excessive. These extremes are

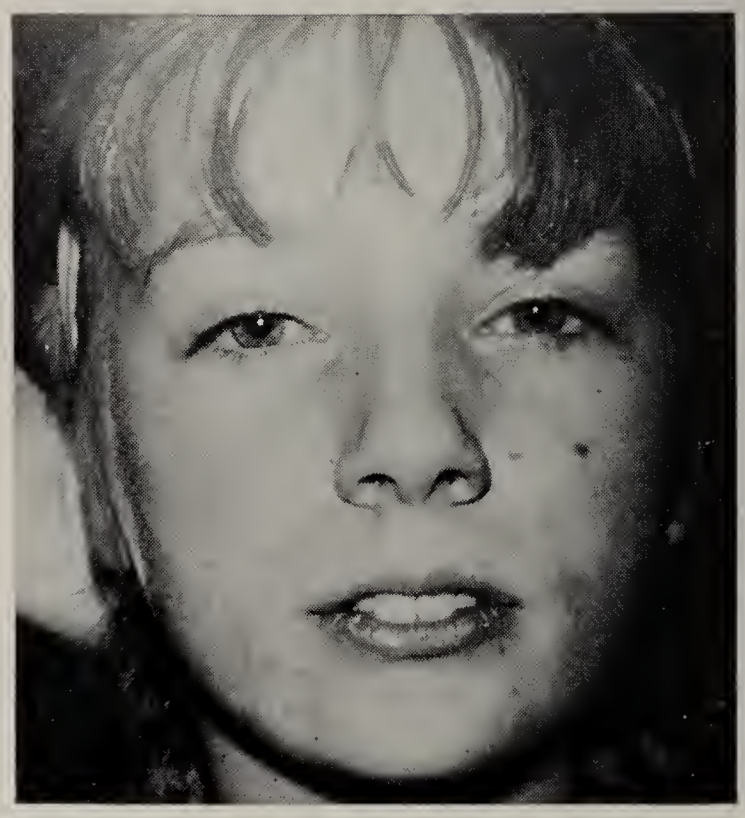
A

B

C

D

E



F

Fig. 14.—A, Grinding: before. B, Grinding: after. C, Grinding: withheld. D, Accepted irregularity. E, Accepted (?) irregularity. F, Accepted (?) irregularity.

normally associated with a high and a low Frankfurt mandibular angle, but generally cases with high and low Frankfurt mandibular angles, have adequate soft-tissue covering.

The so called ' short upper lip ' is usually an upper lip unable to function normally because of superabundant lips, had a Class II, division 2 occlusion.

Finally, a study of beauties through the ages emphasizes the variety in what has been and is considered beautiful. Size and shape of the hard and soft tissues varies enormously. There are

A B C D

Fig. 15.—A, ' Short ' upper lip. B, ' Short ' upper lip? C, True short upper lip. D, Superabundant lips.

the proclined upper incisors. When these teeth are retroclined the lip ceases to be ' short ' (*Fig.* 15A, B). The truly inadequate lips are comparatively rare and are usually not helped very much by orthodontic treatment.

The boy in *Fig.* 15C had a Class II, division 1 malocclusion, whereas the girl in *Fig.* 15D, with obviously fashions in beauty beyond those which can be contrived by powder and paint. Queen Nofret the Beautiful (twenty-eighth century, B.C.) was severely Skeletal II. Queen Nefertiti (fourteenth century, B.C.) had a magnificent profile. Botticelli's *Venus* (sixteenth century) has most beautifully proportioned hard and soft tissues, a

rare example, like Lady Brownlow, of beauty transcending sex. Michelangelo made a drawing entitled, *Head of an Ideal Woman.* She is a most formidable creature with strong masculine features. In the next century Lely's portrait of Nell Gwynn is in great contrast. The face is soft almost to weakness and has a double chin which was then fashionable. In the eighteenth century Goya's *Donna Isabella* shows robust beauty with well developed nose, lips, and chin, and relatively receding dentition. Two portraits by Ingres in the nineteenth century vary widely. Madame Moitessier has a face with a big total height, small dental height and probably a high F.M.A., whereas Mademoiselle Rivière is a Class II, division 2 type with superabundant lips. In Victorian days Rosetti immortalized Beatrix (Skeletal III) while in our own time Miss World 1967, from Peru, is a textbook normal.

Acknowledgements

I should like to thank the many people who have helped me, including my long-suffering family and especially my wife who made many of the slides from which the illustrations were prepared. A great many colleagues have contributed generously. Professor Percy Horton, artist and former Ruskin Master of Drawing, Oxford University, and Mr. W. J. Strachan, author and leading authority on Modern French Art have given me guidance and inspiration. Miss Spencer, the British Dental Association Librarian, Mr. Sykes of the Bradford Central Library, and Mr. Kerslake of the National Portrait Gallery have been of the greatest assistance. My thanks also are due to Mr. Henry Moore, Lord Lumley, and Mr. Patrick Matthews. The help and enthusiasm of Miss Stevens and Mr. Scatliffe is much appreciated.

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DISCUSSION

Mr. R. E. Rix in opening the discussion noted that, early in the address, the President was prepared to settle for ' beauty is in the eye of the beholder ' and to abandon the science. He agreed entirely that although man had an intuitive appreciation of beauty in his fellow humans and in much of his familiar environment, it could not be reduced to precise scientific formulae. He had found it difficult to follow Eric Newton's phraseology when he said that beauty in nature was the product of the mathematical behaviour of nature, which in turn was a product of function. Man's intuitive appreciation of beauty received a jolt, of course, at the sight of an alligator, whose mathematics were no doubt faultless. Since beauty was in the eye of the beholder, he did not think it could be independent of time and period, as the President had suggested. Taste and fashion could condition standards.

If the present trend continued, the slide of the beauty queen with a Class II dentition suggested to him a sinister falling off in the demand for orthodontic treatment. From the President's speculation as to her other attributes, it might be that demand would be in inverse ratio to the degree of exposure.

He was not surprised when the President said that cheek teeth did not have to be in anything like normal number, occlusion, and alinement. He could not remember a case where reduction in chewing capabilities was leading to nutritional disorders. The importance of function lay in its long-term by-products of comfort and durability of teeth.

Had the President not been a little hard on Professor Ballard, when commenting upon his Northcroft lecture? He did not think Professor Ballard meant to return matters to square one. He had said that his eye was sufficiently practised to avoid the use of profile radiographs in ascertaining critical relationships between the occlusal plane of the lower cheek teeth, the lower lip, and the upper incisors. Because he could use his eye, he did not abandon his claim for the usefulness of some applied geometry to foretell what compromises with nature were feasible and what were not.

When the President had elected to sacrifice a small lateral incisor and to close the gap, had he sometimes had difficulty in ensuring that the long axis of the canine remained in parallel with the long axis of the central? In the past, he had tried to save and crown a small lateral where possible, even in a Class II dentition requiring premolar extraction. In an animated and expressive face, one's expectations of symmetry were not satisfied, he felt, with five front teeth. Another disappointment could arise, he found, from the increased labiolingual width of the canine. Where

the overbite was other than slight, the canine finally assumed a more prominent position than the lateral on the other side, itself a thinner tooth and often, therefore, slightly instanding.

The President, in reply, said he thought the point about mathematics was that nature was functional and this functional behaviour was subject to mathematical analysis. Beauty was an expression of the mathematics of nature so that full appreciation of beauty was limited by mathematical knowledge but was enhanced by experienced intuition.

On the question of fashion in beauty, Nofret the Beautiful was clearly Skeletal II. It was certain that no ladies were going to show their faces at court if they stuck their chins out. In the later period of Queen Nefertiti, it was respectable to have a good chin. Then Charles II definitely did not like chins—or he liked a lot of little ones—so there was again another fashion. You were out unless your chin was in! Coming down to Victorian times exemplified by Beatrix and Miss Hawthorne chins were well out again. Finally, Miss World was the textbook normal.

He was interested in Mr. Rix's point about teeth meeting. Professor Liddelow had demonstrated in his beautiful film on chewing that the teeth were nowhere near in occlusion during mastication.

He would never presume to be hard on Professor Ballard whose apprehension and intuition were very much more highly developed than most orthodontists. Although Professor Ballard took these lateral skull radiographs, he probably did not need them; he said that himself.

Mr. G. C. Dickson made the point that throughout man's evolution the cusps had, at an early age, been worn away from the cheek teeth. It is not to be expected, therefore, that correct interdigitation of cusps is a necessary requisite of orthodontic treatment.

Mr. J. C. Ritchie wondered if the President would agree that orthodontists should always be on their guard not to destroy character. Over the years, as the orthodontist looked at many patients, he began to realize that although he was taught to strive for perfection in tooth and arch relationship, perfection could, in some cases, be a great mistake. He was thinking particularly of some parts of the world where orthodontics patients, after treatment, had the ' orthodontic look '. Indeed, the ' orthodontic look ' was almost advertised as a position of ultimate success and, yet, in those countries, one saw many, many patients all ending up looking the same.

Mr. E. K. Breakspear had three practical points to make. First, he would not in any way regard stoning to improve the appearance as cheating. He would rather look upon it as ' occlusal editing '.

Secondly, while in many cases the improvement of appearance might not affect physical health, it might very much affect mental health, and the patient whose schoolmates called him ' Goofy ' or ' Tusker ' or something like that might be very much improved in his mental and emotional state by prompt treatment.

His third point was that he entirely agreed with the President that it was a good thing to have a supply of photographs of noted beauties with slight irregularities. At one time, he kept a photograph of an air hostess on an Aer Lingus brochure, who had an Angle's Class II, division 2 occlusion. It looked quite attractive and he kept it in his drawer against possible relapse!

Mr. F. Allan said that if in order to achieve a good occlusion, many perfectly good teeth were extracted, like the first two premolars, it was often the case that one should not have touched them in the first place, particularly if spaces were left, and the occlusion was far from perfect, due to the orthodontic treatment carried out.

The question of beauty, however, was one of degree in each particular case. One did not have to look at perfect examples of beauty to find out what one could achieve. One had to look at each individual and see how much one could improve the looks in certain ways.

The profile was taken into consideration much more in the United States where the question of extraction was determined by the profile and its improvement. One point was that if there were no extractions, the profile might become fuller. If the profile was already flat, anterior extractions would make it worse. There was a good case for knowing what kind of extractions to do in order to help a profile rather than destroy it.

With regard to interdigitation of teeth, he did not know why this concept was so attacked. He found it a help rather than an enemy. If he knew that the interdigitation was right, that is, also in the right place, then he knew there was reasonable space for the front teeth. It had happened occasionally that he got good interdigitation with lack of space for the front teeth, or too much, but this did not happen often.

To say that a case may lose character with a good orthodontic result was something he could not understand. If a patient had beautiful interdigitation and well alined front teeth, then this was the ideal one looked for in people.

Mr. C. D. Parker stated that his primary objective in orthodontic treatment was the establishment of a good working or functional occlusion. Such an arrangement of the teeth was easily cleaned by the child and maintained by the dentist. It may well be that there was a range of good working occlusions and that more work would have to be done to identify this. However, he said that he found it difficult to accept as satisfactory a pleasing appearance of the anterior teeth associated with a poor buccal occlusion. On the other hand, with the establishment of a good functional occlusion, he had found the aesthetics to be acceptable, although it may not coincide with an arbitrary aesthetic standard which had varied through the ages and which, in many cases, was unattainable.

The President, in reply, said that on the question of stability he must unwittingly have put the cart before the horse. The arrangement of the incisors was no good at all unless it was stable and stability was a parallel requirement of whatever was done to the incisors.

He was encouraged to hear what Mr. Ritchie had said about character. Since he started trying to get outside the mouth and look at the teeth from outside, he had learnt a tremendous amount. People did not want many of the things orthodontists thought they wanted. There was the mother of the girl with the long centrals, a very intelligent woman, who had rebuked him sharply for trying to shorten those incisors to make them look even, like Miss World's. He had been very impressed.

Mr. Allan referred to the profile. This was not as important as one would imagine, the reason being that in everyday life we hardly ever saw one another in profile, which was probably a good thing. Only 4 per cent of portraits in the National Portrait Gallery were in profile. There was a period when the silhouette was important. This was the poor man's

portrait superseded by the photograph. It was an uncompromising dead profile shadow of the face usually cut out of black paper.

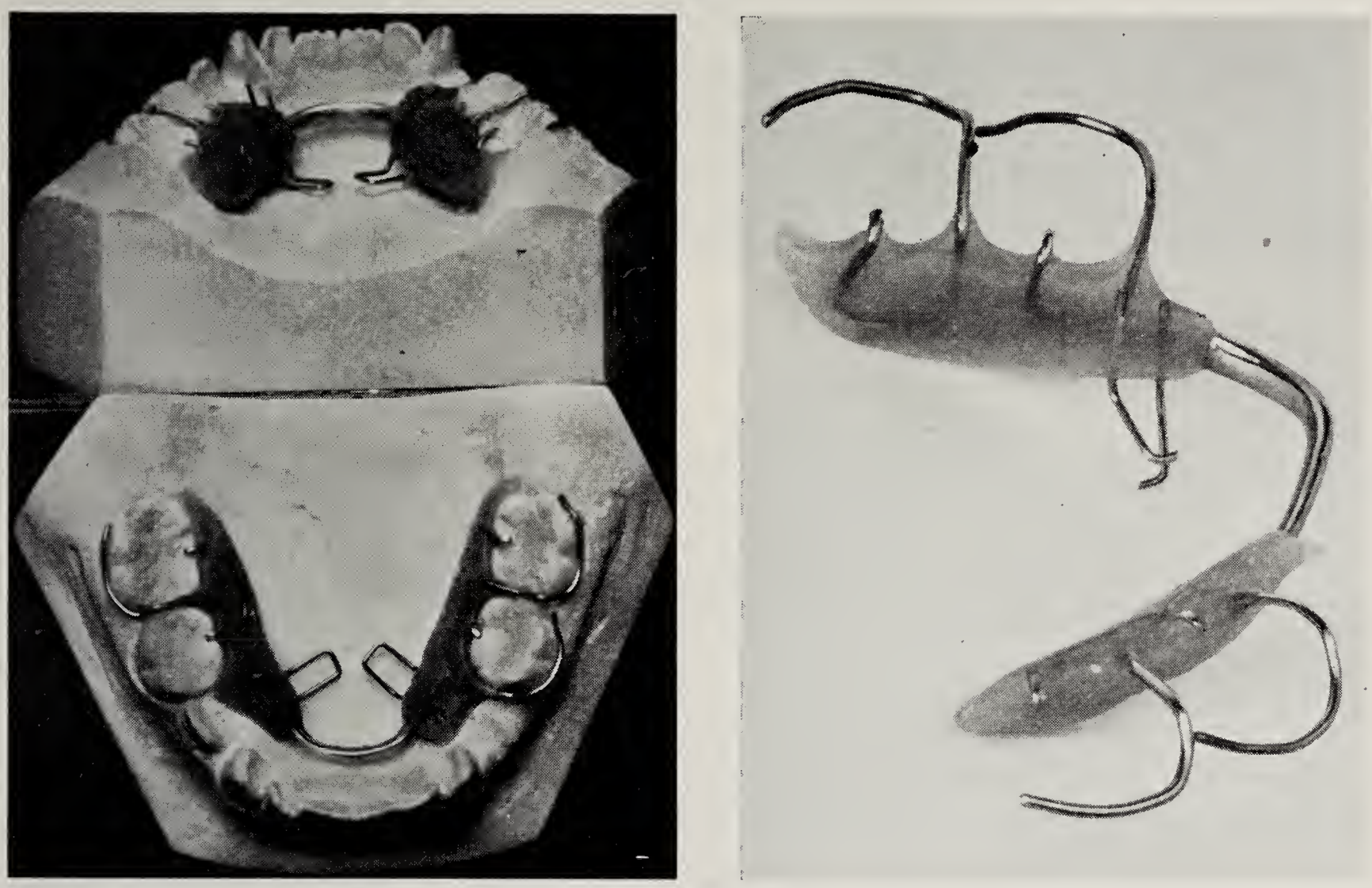
He must have misunderstood Mr. Allan, but he could not see that good interdigitation of the cheek teeth and good incisor alinement were interdependent. One frequently saw one without the other.

He found he nearly always agreed with Mr. Parker, but could not on this occasion. Repeated enquiries from patients had revealed that function is not a problem. Even the dreadful Skeletal III cases with literally only two contact points in occlusion when asked ' have you any trouble eating your food? ' invariably replied, ' No '. It was very rare to find individuals even with appalling occlusions having any trouble. This is no doubt partly due to the wonderful way in which the body adapts to abnormality.

THE MOVEMENT OF LOWER INCISORS USING MODIFIED CROZAT APPLIANCES

JOAN RITCHIE, L.D.S., D.D.O.

The case being presented is one where there was ectopic eruption of both lower lateral incisor teeth. Both had erupted in the position of the first premolars with a history of natural exfoliation of the first deciduous molars.



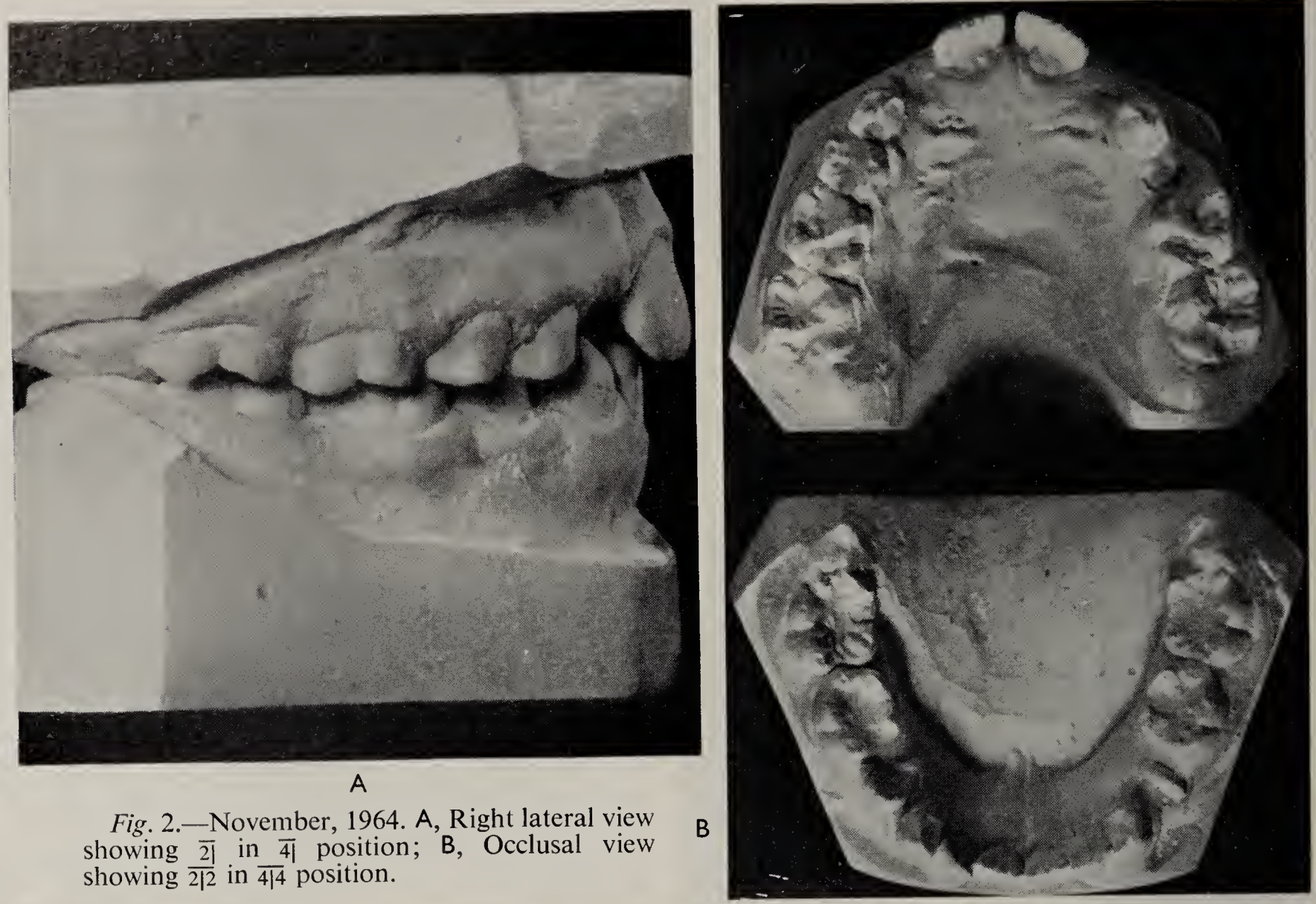
A B

Fig. 1.—A, 0·1-mm. thicker wire with parallel end inserted in wax prior to flasking and processing; B, Removal of thicker core, cut at ' U ' bend and pulled out, leaving parallel holes for insertion of spring wire.

THE APPLIANCE

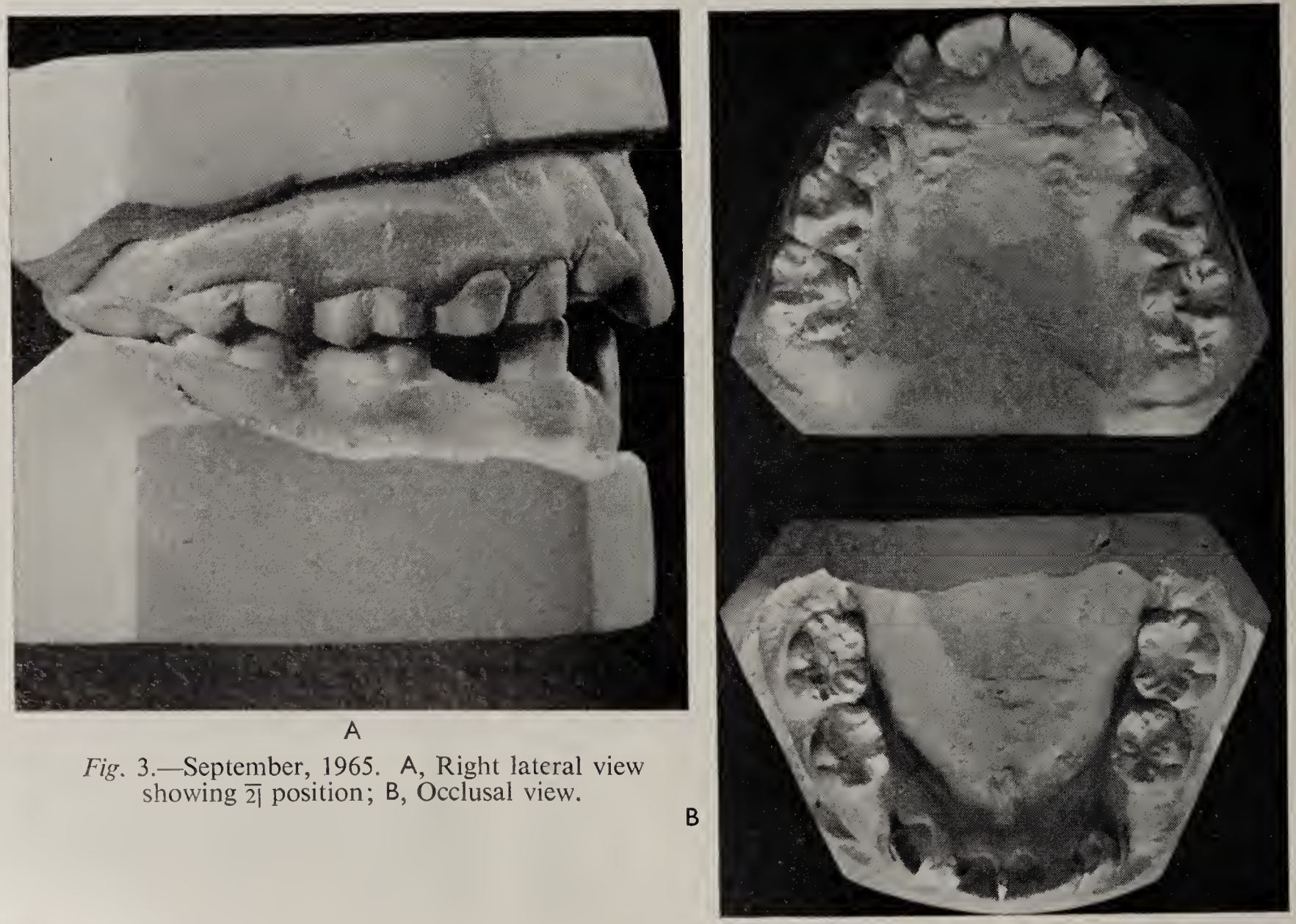
The appliance used in this case report is a modification or, more truthfully, an adaptation of a modification of the Crozat appliance. The Crozat appliance has been described by Salzmann (1966) as being a modification of the removable appliance originally employed by Victor Hugo Jackson, and first described by him in 1887 and later in greater detail in 1904. Dr. Crozat first described his modification in 1920. It was constructed of precious metal, was removable, and had auxiliary springs soldered directly to the main appliance. It was used both in the upper and lower dental arches. The late Mr. Russell Marsh (1951) described his modification of the lower Crozat appliance making use of stainless-steel and silver solder. The silver solder was used for ' massive ' solder to form a basic skeleton of oval stainless-steel wire with horizontal tubes which carried the required auxiliary springs or, alternatively, finer tubes to carry further springs. The spring wire was crimped or compressed slightly into the tubes in order that the wire could be, to quote Mr. Marsh, ' wedged tight '. As the basis for any removable appliance must be a

Presented at the meeting held on 9 December, 1968.



A B

Fig. 2.—November, 1964. A, Right lateral view showing $\overline{2|}$ in $\overline{4|}$ position; B, Occlusal view showing $\overline{2|2}$ in $\overline{4|4}$ position.



A B

Fig. 3.—September, 1965. A, Right lateral view showing $\overline{2|}$ position; B, Occlusal view.

satisfactory anchorage, the stainless-steel modification of the Crozat appliance had its limitations, particularly where the anchor teeth were extremely shallow.

The appliance was an adaptation from this. It is constructed of an oval, stainless-steel, lingual wire—Ash's No. 1 oval stainless-steel wire is used. This is 1·524 mm. thick and is embedded in acrylic in which are fine parallel holes for the insertion of the auxiliary springs (*Fig.* 1). These are 0·1 mm. greater in diameter than the spring to be used. After processing, this wire is easily removed by cutting at the 'U' bend. If required, there can be two lots of parallel holes on each side of the appliance. In practice, as 0·5-mm. stainless-steel wire is used for the springs, a wire of 0·6-mm. diameter is used for the core. It can be seen that a variety of springs can be inserted in this basic skeleton.

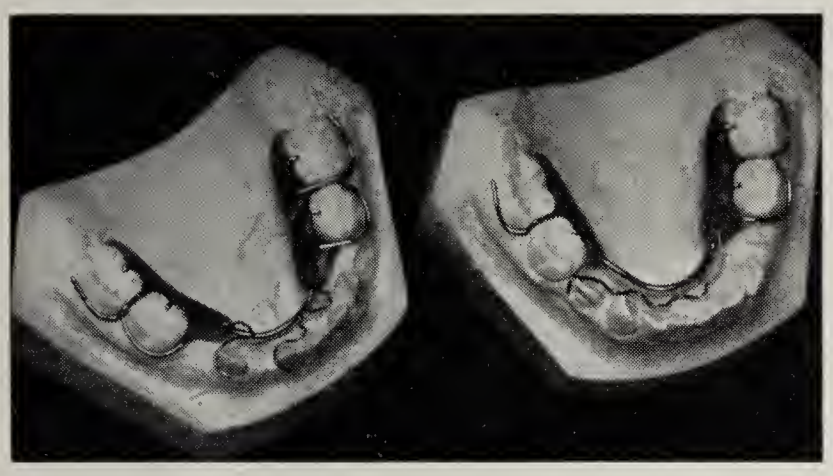


Fig. 4.—On the right, the first appliance used; on the left, the second appliance used.

This appliance is designed to be worn at nighttime only. One reason for this is to reduce the risk of distortion of the springs. Should distortion occur, there is little risk of damage to the teeth through too great pressure, as the springs will almost always jump off the teeth, or over the teeth. In this eventuality the appliance cannot be seated. Should this happen, patients are instructed to post the appliance for repair. Repairs or replacement of springs take a matter of minutes. The working model, incidentally, is always kept.

This is an extremely useful appliance, particularly where patients are away from parental supervision. It is simple, easily tolerated by the patient, and easy to clean; oral hygiene is no problem—I should say, no more of a problem than is normal with schoolchildren!

Ideally, one would use Adams's clasps wherever possible. However, in the case being shown, these were considered impracticable due to the extremely shallow molar teeth.

CASE REPORT

The patient was first seen in 1964 at the age of 8 years 3 months. She was diagnosed as Skeletal I, with a tendency towards prenormal relationship of the deciduous canines. A note was made that she was extremely caries-prone.

The $\overline{2|2}$ had erupted in $\overline{D|D}$ position. The $\overline{|2}$ was rotated through an angle of 90° (*Fig.* 2A, B). The proposed treatment was to have $\overline{CB|2}$ extracted, and then to move $\overline{2|}$ mesially. The first lower appliance was fitted in January, 1965, after the extractions had been carried out. In July of that year a fresh spring was inserted in the appliance.

Fig. 5.—June, 1967. Lower model showing position when appliance was discarded.

Fig. 6.—October, 1968. Showing final lower model.

In September, 1965, in view of the X-ray picture of $\overline{3|3}$ and the fact that $\overline{3|}$ could be palpated buccally, it was decided to continue the mesial movement of $\overline{2|}$. At the time, the extraction of $|\overline{BC}$ was advised (*Fig.* 3A, B). The original appliance and same spring were used until July, 1966, when a new appliance was fitted. This was designed to move $\overline{1|1}$ to the left, and to continue the mesial movement of the right lateral. Active movement of this tooth was completed by the beginning of December, 1966, although the patient wore the appliance to hold the lateral incisor in position until $\overline{3|}$ was about to erupt.

The two appliances used are similar in design. (*Fig.* 4). The original was made before $\overline{CB|2}$ were extracted. It was necessary to grind the mesial surface of the filling in $\overline{E|}$ in order to seat the spring round

the distal of $\overline{2}|$. The spring was adjusted at the 'U' bends. The second one used, made up before $\overline{|BC}$ were extracted, had one spring to move the lower central incisors to the left, and a second spring coming from the right side of the appliance, to continue the mesial movement of the right lateral.

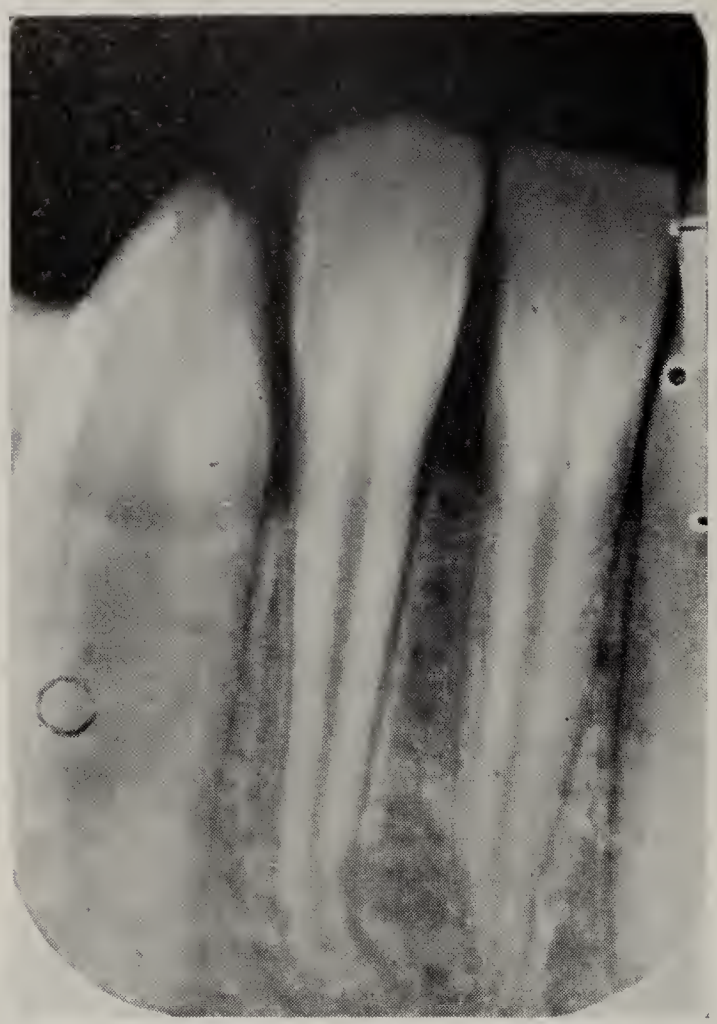


Fig. 7.—October 1968. X-ray showing apical condition of $\overline{2}|$.

In June, 1967, the lower appliance was discarded (*Fig.* 5). At that time there was barely enough room for $\overline{3}|$, and I was considering advising the removal of $\overline{E}|$ and adding a spring to encourage $\overline{4}|$ to move distally. However, between visits the patient managed to extract the tooth herself. It was decided to keep the case under observation, and the appliance was discarded.

By October, 1968, $\overline{534|345}$ had erupted (*Fig.* 6). The $\overline{2}|$ was tested and X-rayed (*Fig.* 7). The tooth is still vital.

DISCUSSION

Measurement by Vernier gauge on the models shows that the right lateral was moved 12 mm. For this there were 21 monthly visits and 2 appliances. On reflection, monthly visits for adjustment were not essential—except possibly for the psychological point of continued interest. With regard to the overall treatment of this case, as the upper lateral incisors were smaller than average, the extraction of upper premolar teeth was contra-indicated especially in view of the fact that the patient was caries-prone. In addition, later X-rays showed the wisdom teeth to be of doubtful quality. It was felt wiser not to extract in the upper arch. The final models show a good occlusion on the right side and a tendency towards a prenormal occlusal relationship on the left.

Acknowledgement

In conclusion, I should like to express my thanks to my technician, Mr. Wilsdon, without whom the adaptation described here would not have been devised—nor would I have had his help in preparing models and appliances for this paper.

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DYNAMIC-FUNCTIONAL APPLIANCES

H. L. EIREW, L.D.S., B.D.S.

When the editor invited me to participate in this meeting it was suggested that I might present some cases treated by dynamic-functional appliances. I have used this system with good success for over 15 years now and it is a constant source of surprise to me how little it is known and used in this country, despite sweeping conquests in Europe and, to a lesser extent, across the Atlantic.

Recently there has been a welcome surge of interest, particularly in Scotland where several people have started to use the Fraenkel appliance. Moreover, this will be one of the chosen fields for discussion at this year's Congress of the European Orthodontic Society. It occurred to me therefore that, rather than show you one or two disconnected cases, I should briefly review the development of the whole system and my personal involvement in it. In the few pages at my disposal the account must, of necessity, be entirely superficial.

The first is a simple activator case, with forced extraction of the first molars (*Fig.* 1). The sole notable feature is that treatment was completed in only 3 visits and a total time expenditure of about 40 minutes, due one should say, to the patient's prolonged illness and two-year detention in hospital. The point I am really trying to make is that, in suitable and fortuitous cases of this kind, the Andresen appliance is virtually the world's best, because of the following factors:—

1. It is cheap and easy to make, particularly by the new cold-cure method.
2. It is easy to use for both the patient and operator.
3. It is gentle and safe in action.
4. It needs almost no adjustment.
5. It is virtually indestructible.

Unfortunately there are also many failures, some, no doubt, due to incompetence and lack of clinical experience, to faulty case selection, and poor co-operation, but, in many cases, due to the sheer inherent limitations of the appliance.

Over the years it has not been helped by the dogmatic insistence of the leading academics in this field, that the pure functional character of the appliance must be preserved at all cost, to the exclusion of all active components. We do, of course, meet activators with auxiliary springs, screws, and even extra-oral traction, but these are strictly against the traditional rules.

My own experience in this field goes back to the early post-war years, when not only the appliance but even its few protagonists had to face a great deal of sceptical and sometimes downright ribald comment. The phrase 'the Board does not believe that . . .' still rings powerfully in my ears. Thanks to the efforts of Rix (1966), Grossman (1947; 1964), and others a measure of acceptance has now been established.

Fig. 1.—Case treated by functional appliance and unavoidable removal of first permanent molars.

In the early part of the last decade I first came to hear of Dr. Bimler's theory of dynamic-functional treatment, through a reprint given to me by Dr. Mills (Bimler, 1950). Bimler's ideas, first put forward shortly after the last war, run roughly on the following lines: if, in chewing some soft food, say a fruit pie, one were suddenly to bite on a hard object such as a cherry stone, one would expect the tremendous forces of mastication not only to shatter the stone but also the adjoining dental structures. That this does not in fact happen is due to the existence of a lightning reflex which, so to speak, slams on the masticatory brakes before damage is done.

It occurred to Bimler that since the conventional activator is also a hard foreign body, it might well elicit the same reflex and thereby inhibit the very muscular activity on which its action depends. To verify this point he experimented with a number of elastic activator-like structures, some made from soft rubber and others with springy wire skeletons, and was able

Presented at the meeting held on 9 December, 1968.

to demonstrate their increased effectiveness and speed. Over a period of years he then evolved the appliance system now collectively known as the Bimler appliance (*Fig.* 2).

This is, in fact, an activator broken down into its various force components, and then built up again in elastic springy form with a number of acrylic and rubber supporting structures. Constructed in a conventional working bite, it uses

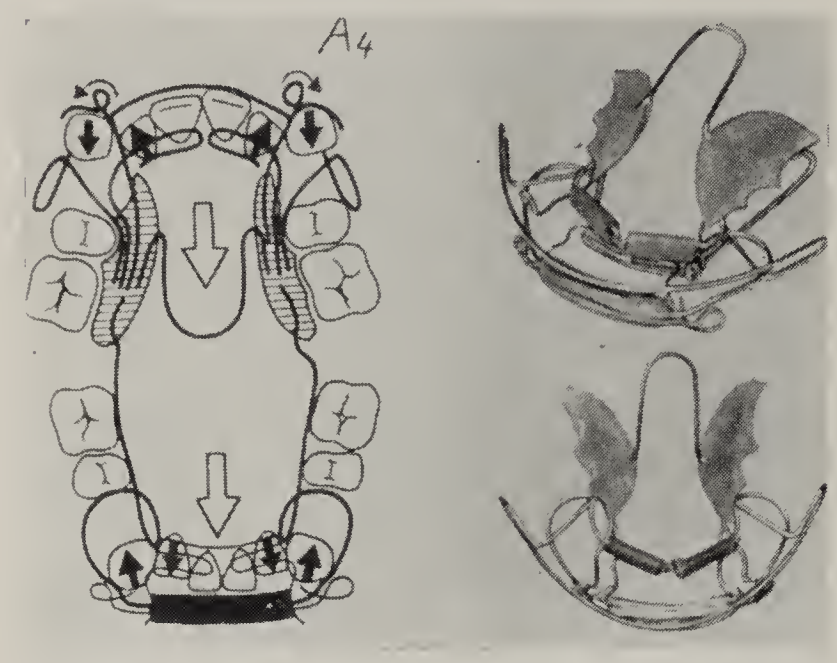

Fig. 2.—Bimler appliance, Type A4. (*Reproduced by permission of the Editor from ' Fortschr. Kieferorthop.'*, **25**, 121.)

functional muscular pressure to bring into play the active forces built into the appliance. In this sense it constitutes a great technical advance over the conventional Andresen appliance, and this type of activity is now named ' dynamic-functional '.

I was so intrigued by this new concept, that I arranged to visit Bimler and to spend some time in his practice at Wiesbaden. What I saw there impressed me immensely. The practice, the size of an average hospital department, treated very large numbers of patients, and almost entirely by Bimler's method. Many of them were children of American diplomatic and service personnel from all over Europe, familiar with the best of orthodontic therapy and yet, as far as I could see, extremely happy with their treatment there. Progress and results were excellent and I was particularly impressed by Bimler's own candour in discussing his problems and failures, which to him seemed almost of greater import than his successes.

On my return I threw myself into this work with my usual excessive first enthusiasm. I even made a Bimler appliance for myself to experience the sensation of wearing it. On insertion one was immediately motivated to bite into it and to ruminate, chewing-gum fashion. This exercise was extremely pleasant and of obvious clinical benefit. The sensation is best described as ' like chewing a spring interior mattress '. This heavy working with the appliance cannot be reproduced with a solid activator.

Another obvious advantage over the activator is the freedom of lateral jaw movement in addition to the normal vertical activity. This regular powerful sideways pressure of the jaws against the elastic appliance results in marked lateral arch development, which is a common feature of all these elastic appliances. This arch-widening appears to be remarkably stable, and since I do not believe in the feasibility of artificial expansion *per se*, it is my view that these elastic appliances simply stimulate each patient to attain his own innate optimal growth potential.

I employed the Bimler appliance for several years with very useful clinical success, but, as always, there were drawbacks. The appliance is difficult to make and therefore costly. Clinical control demands a good deal of supervision, skill, and experience. Most important of all, due to its skeletal nature, the appliance is easily distorted or broken. Readjustment or repair is very tricky indeed. In Bimler's own practice, geared entirely to the one method, these problems were not significant. At the time of my visit he employed a dozen or so lovely young girls, each trained to deal with one small part of the assembly. In consequence they were able to cope with repairs most effectively, but since my circumstances precluded a commitment on this scale, my troubles persisted. After some years my interest paled and now I only use the Bimler appliance in a sturdier modification of my own for the treatment of Class III malocclusions.

Bimler's success encouraged a large number of imitators. Many new appliances were described, based on the same principles but entirely different in form. Of these, I would like to highlight just two, which have made a great impact abroad and are clearly destined for further development: the Fraenkel and the Kinetor.

THE FRAENKEL APPLIANCE

The Fraenkel appliance, also known as the functional regulator or FR for short, has lately found a keen protagonist in Dr. Russell Logan of Edinburgh. There are three versions, known as FR I, II, and III for the respective treatment of Angle's Class II, division 1, Class II, division 2, and Class III (*Fig.* 3). You will note the bulky acrylic elements placed in the buccal and labial vestibular areas, where they are used to harness or screen off muscle pressure from selected areas, thus permitting the tongue pressure from within to exert greater influence. These labial screens are placed inside the lower lip in Class II and inside the upper lip in Class III. They push firmly into the vestibular fold, thus not only correcting lip posture but also, according to Fraenkel (1967), exerting a strong pull on the lip muscle insertions, thereby stimulating further bone growth.

Fraenkel attaches great importance to the role of the tongue and opposes the placing of any bulky appliance parts in the tongue space. He claims that many malocclusions are due to the failure of the tongue to fully occupy the anterior oral space. By making his appliances in edge-to-edge bite he stretches the floor of the mouth and draws the tongue forwards. This, in his view, then produces a normal growth stimulus and latent development in this vital anterior region. Whether one agrees with these theories or not, there is no denying the tremendous potency of these strange looking appliances. I have now used quite a large number, and their success, particularly in extreme cases, is truly astounding.

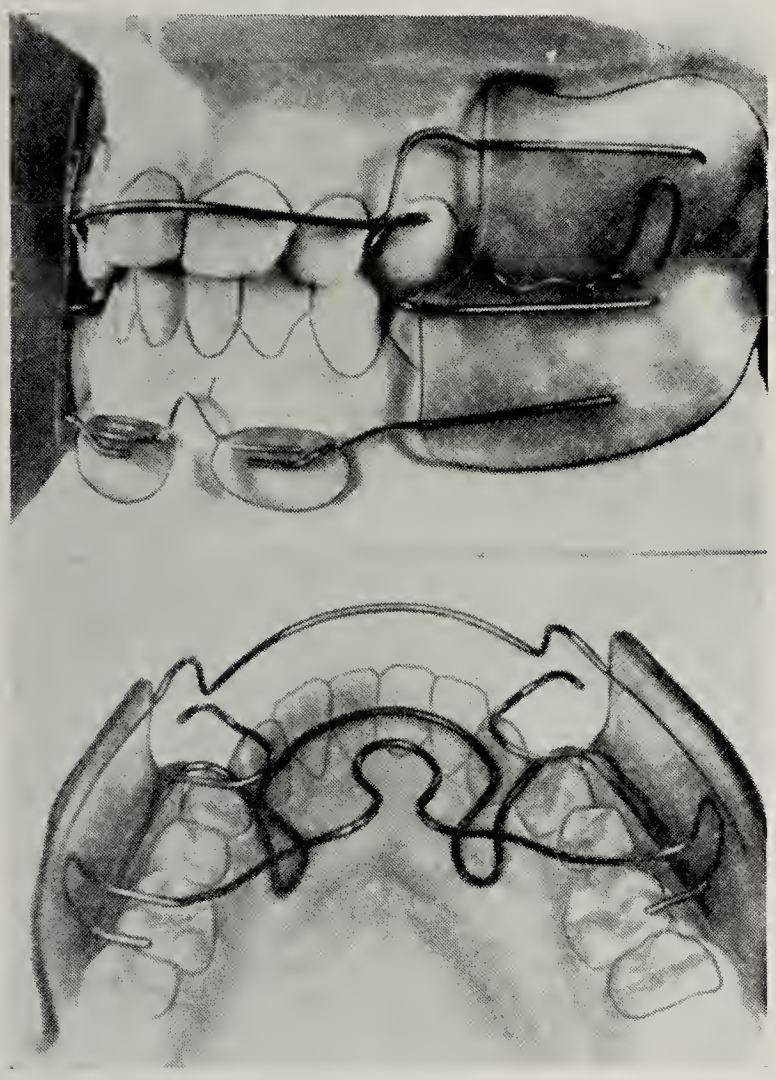

Fig. 3.—Fraenkel appliance, Type FR I. (*Reproduced by permission from Fraenkel, R., 'Funktionskieferorthopaedie und der Mundvorhof als apparative Basis'. Berlin: Verlag Volk und Gesundheit.*)

One of the most remarkable experiences in orthodontic practice is to witness a patient's first ever insertion of an FR. The appliance is large in circumference and is invariably made in edge-to-edge bite, which severe cases of Class II or III only reach with the greatest difficulty and stretching. First insertion can, therefore, be quite a struggle, at the end of which the patient's face may be screwed up and contorted by muscle spasm and anxiety. Then, during the next minute or so, as one speaks quietly and reassuringly, a remarkable transformation takes place. The spasm relaxes, the whole face seems to soften and melt into a new shape, disguising the malocclusion and the unsightly lip posture. To a watching parent this can be a most impressive and moving experience. Even my staff, who have seen it happen many times, like to be present at these performances, which oddly remind me of the transformation of Count Dracula, in the well-known horror film.

Logan (1966), drawing his inspiration from the disciplined Eastern European source of the apparatus, insists on full-time wear. My own patients have a dispensation for school, sport, and social activities.

I have no doubt at all that this appliance, in the next 2 or 3 years, will be one of the major talking points among orthodontists, but I would make two important notes of caution. First, the appliance is even more difficult to make than the Bimler and therefore costly. My best technician, a very experienced man in this field, requires the equivalent of a whole working day to produce each one. Secondly, one is often asked for an old appliance by friends wishing to copy it. Whereas one might approve of this procedure with other devices, I would strongly warn against it with the FR. There are so many subtle points in the construction, so many individual features to be observed for each case, that the mere copying of someone else's discarded appliance, or the obtaining of a standard model from a mail-order laboratory would be courting failure. It is this sort of blind tinkering which can bring a sound technique into disrepute, as proved years ago by the activator. Fraenkel's own textbook (1967) is painfully difficult to follow, even for those with a reasonable working knowledge of the German language. Anyone falling short of this should leave the appliance well alone, at least until an English translation or working manual is available.

THE KINETOR

Finally (*Fig.* 4) the Kinetor, first introduced by Dr. Hugo Stockfisch in 1953. This I regard as the most highly developed and most practical dynamic-functional appliance at the present time. Its main merit lies in the fact that most of its component parts may be purchased in prefabricated form (*Fig.* 5). Kits are obtainable for one, three, or ten Kinetors, and a reasonably skilled person, although not necessarily a dental mechanic, can assemble an appliance in about an hour, joining the provided plastic components on the models by means of cold-cure acrylic, and then hooking the most important wire parts, also in the kit, into the various slots and holes provided. Adjustment is carried out either by bending of the wires, or by their reinsertion in a different hole in the plate. Broken or damaged wires are detached and replaced by spares in mere seconds.

Each appliance consists basically of 2 plates, upper and lower, connected by a hinge on each side (*Fig.* 6). The hinges orientate the plates in a working bite to each other, a bite which may be advanced or retarded during treatment as desired,

Fig. 4.—The Kinetor.

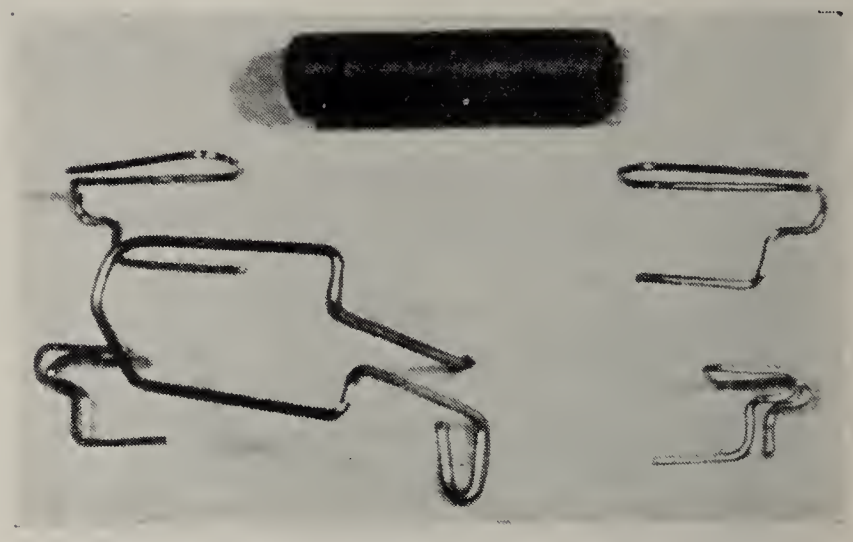

Fig. 5.—Prefabricated Kinetor components.

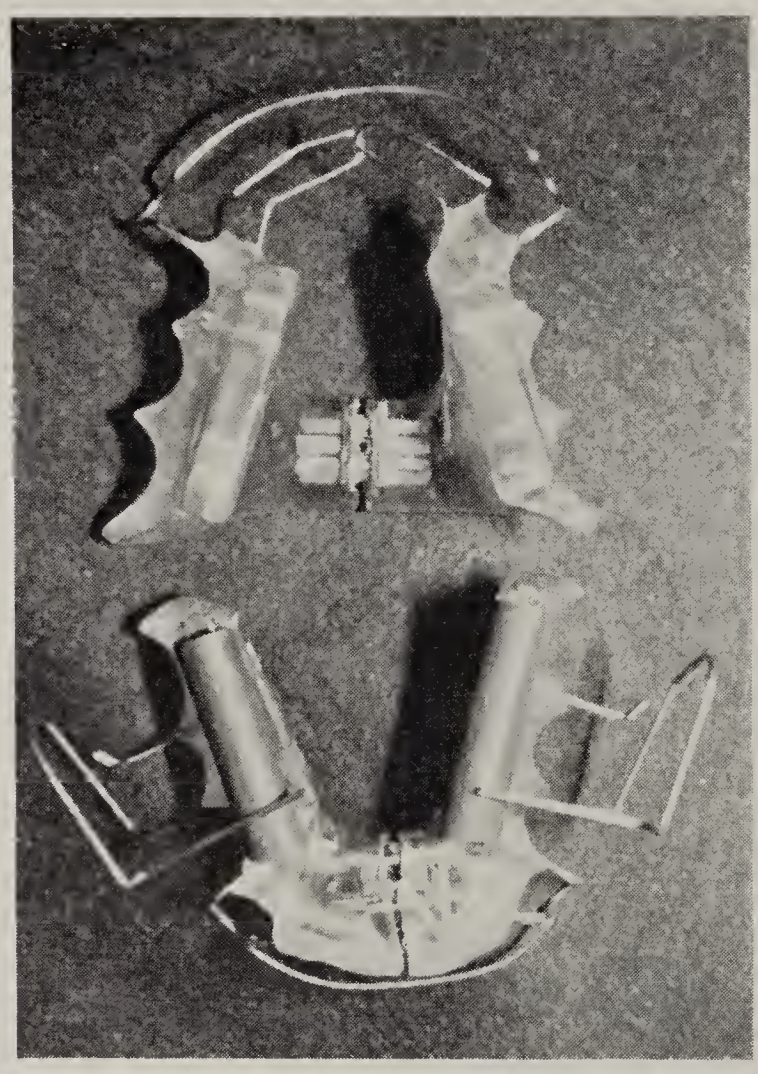

Fig. 6.—The Kinetor: separated upper and lower parts.

by simple adjustment of the hinges (*Fig.* 7). This facility is of particular advantage in extreme cases of overjet, where the gradual advance of the mandible is a great comfort to the patient. The hinges do not lie at the rear end of the plate as in the Bimler or the various hinged activators, where they are uncomfortable and also more prone to fracture. Instead, they are inserted at premolar level and then run along the full length of the buccal vestibule, about 2–3 mm. outside the cheek teeth. In this position they again hold off the cheek musculature, thereby facilitating lateral arch development under pressure from the tongue or an expansion screw.

Both plates carry labial archwires and such additional spring or screw elements as may be

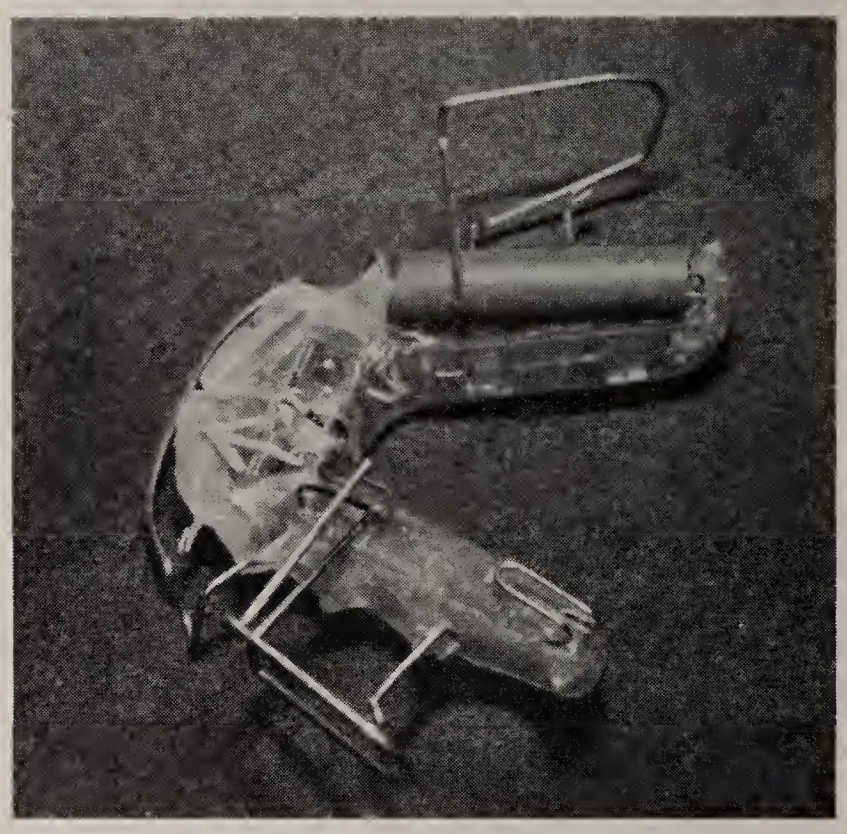

Fig. 7.—The Kinetor: rubber tubing mounted on prefabricated plastic component.

indicated for each individual patient. In open-bite cases a tongue barrier may be incorporated. The ' chewy ' elastic factor is achieved by an unusual method: special hooks on each side of the lower plate carry lengths of rubber tubing from the canine to the molar region. They act as bumpers between the upper and lower plate, and induce the chewing-gum-like stimulus described earlier.

This tubing, when damaged or worn, can easily be replaced by the patient. In normal or deep-bite cases the tubing rests between the plates, just lingual to the cheek teeth. In open-bite cases, where depression of the side teeth is desirable, or in Class III cases, where the bite needs to be gagged, the hooks are rotated outwards through

90°, so that the rubber tubing actually rests between the cheek teeth like an elastic posterior bite gag.

The Kinetor is particularly useful in cases of mild crowding or cross-bite, where an element of lateral expansion is required. At last year's Congress of the European Orthodontic Society at Monte Carlo, Stockfisch (1968) showed a treated case, 5 years out of retention, with a maintained lateral development of over 10 mm. I have been able to produce dramatic arch widening in some of my own patients in the north of England, where we have a high incidence of malocclusion with nasopharyngeal involvement and poor arch development. Since they are all relatively recent cases, I would not wish to produce them here with any claim for long-term stability as yet.

What I can, however, say is this: of the cases I have treated by means of this appliance, some have responded uncommonly well, others have shown normal progress, but none have failed completely, and none have met with patient rejection. Had I, myself, attempted to treat these cases with the conventional Andresen activator, I could not have equalled this record.

There are, of course, innumerable ways of treating standard malocclusion, and one would not suggest that the appliances described here, which to many of you must have seemed like something by Emmett out of Heath Robinson, are in any way superior to the balanced use of traditional methods. For me they provide a lively new interest and a great deal of fun, and I hope these brief remarks have helped to dispel some of the mystique still surrounding them.

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TREATMENT OF A CASE OF AN UNERUPTED CENTRAL INCISOR

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FAILURE of an upper central incisor to erupt is usually due to one of several aetiological factors, e.g., trauma to its deciduous predecessor, the presence of supernumerary teeth, abnormal shape or size of the tooth, dilaceration, odontome formation, and occasionally in cases of cleft palate. In the case described none of these factors was apparently present although the crown of the unerupted incisor was ultimately seen to be slightly larger than the erupted incisor.

Fig. 1.—Models showing condition when first seen.

Fig. 3.—Appliance used to provide adequate space for unerupted tooth.

The patient was a girl aged 9 years 2 months when first examined. She had a Class I occlusion with dento-alveolar disproportion. The upper right central incisor was unerupted and the space for this tooth was partly lost (*Fig.* 1). The upper centre line was displaced to the right. The presence of the tooth was confirmed radiographically (*Fig.* 2), and there was no evidence of a supernumerary tooth. No treatment was undertaken at this time, and after 3 months (as expected) no change in the position of the tooth was seen. It was therefore decided to commence active treatment by first providing adequate space for the tooth, and an upper removable appliance was fitted after the deciduous canine teeth had been removed (*Fig.* 3). Three months later sufficient space had been made, and the crown of the unerupted tooth was exposed under

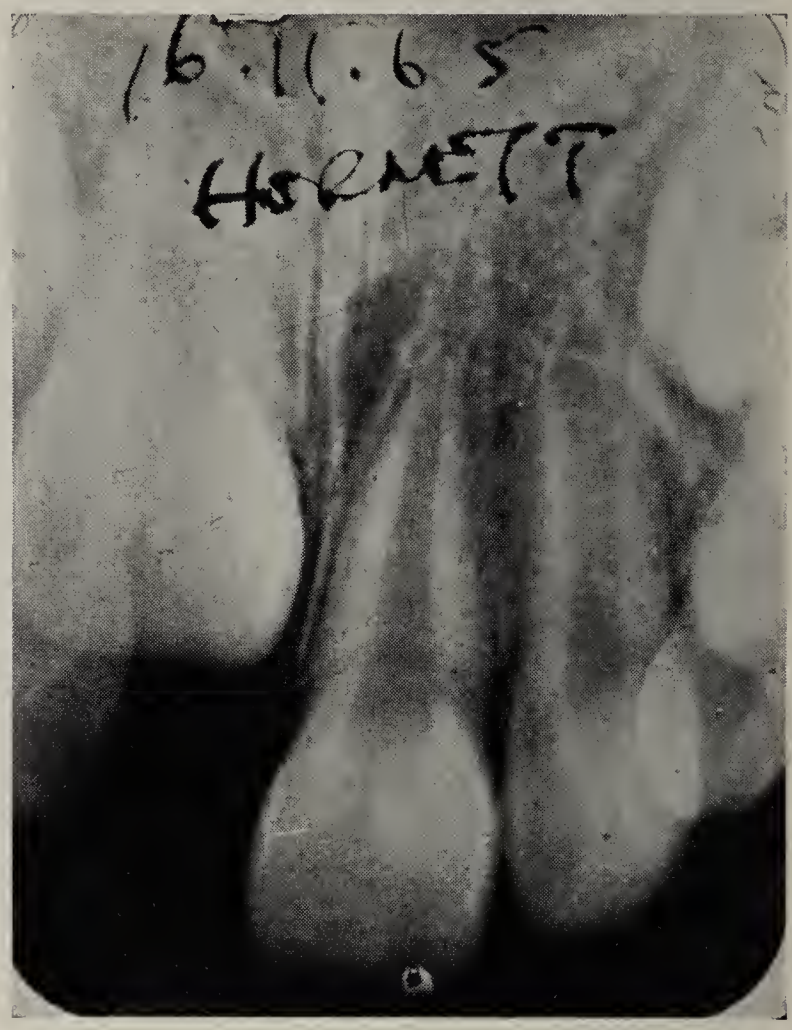

Fig. 2.—Radiograph showing original position of $\underline{1|}$.

Presented at the meeting held on 9 December, 1968.

local anaesthesia. One week later the zinc-oxide–eugenol pack was replaced, and a second pack removed 2 weeks after operation (*Fig.* 4). After a further 2 weeks the tooth appeared to be erupting slowly, and the patient was kept under observation to see how quickly spontaneous eruption would occur, still wearing the appliance to maintain the space for the tooth. The tooth erupted quite rapidly over the next 4 months but with a marked distal tilt, and it was decided to aline the tooth with a Johnson twin-wire arch appliance, modified as described by Mills (1959) to include an auxiliary arch for incisal movement of a tooth placed high in the labial sulcus (*Fig.* 5).

Fig. 4.—Position of $\underline{1|}$ 2 weeks following surgical exposure of its crown.

With this appliance progress was so rapid that after 5 weeks it was possible to dispense with the additional arch, and ligate the twin-arch to the band of the tooth, repositioning the bracket nearer the cervical margin (*Fig.* 6). Seven weeks later the bands were removed, and the tooth was considered to be in reasonable alinement (*Fig.* 7). Extraction of all first premolars was advised after a further 7 months, and the position at that time shows the upper right central incisor to be slightly larger than the upper left, with its incisal edge at a lower level and its cervical margin higher, and no signs of attrition incisally (*Fig.* 8). A year later there had been no apparent change. An occlusal view comparing models of the upper jaw at the beginning of treatment with the present

Fig. 5.—Twin-wire arch appliance with auxiliary arch for incisal movement.

Fig. 6.—Twin-wire arch appliance with both wires ligated to brackets of $\underline{1|}$ band.

Fig. 7.—Eight months after surgical exposure.

Fig. 8.—Fifteen months after surgical exposure.

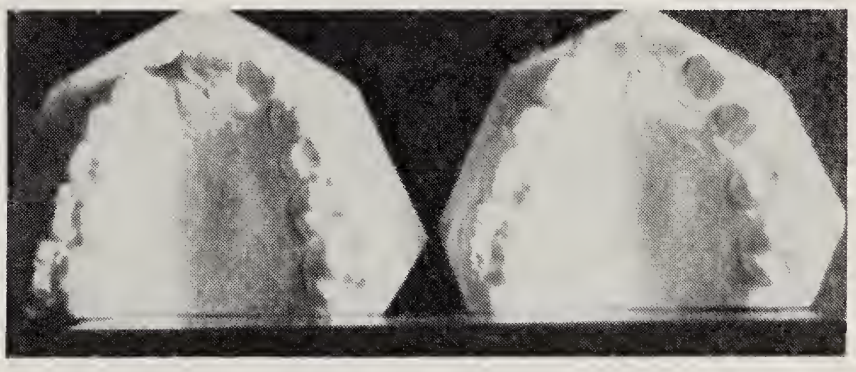

Fig. 9.—Occlusal view of initial and final upper models.

position shows the correction of the upper centre line (*Fig.* 9).

The interesting features of this case are the lack of any obvious cause for the failure of the tooth to erupt, apart from the slight difference in size between the upper centrals, and the rapidity of spontaneous eruption following the creation of adequate space and surgical exposure of the crown. It is a matter for conjecture as to whether the tooth would ultimately have erupted into satisfactory alinement after exposure of its crown without further appliance therapy.

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DISCUSSION

The President asked Mr. Lester what age his patient was and whether the gingival margin would become higher on the left side.

Mr. Lester replied that the patient was 9 years and 2 months when she was first seen in November, 1965, and was therefore now 12. When he saw her recently, the gingival margins of both incisors seemed to be at approximately the same level, but the tooth that had been brought into the arch—and this was something he had spotted only a few weeks ago—was not only wider mesiodistally and longer cervico-incisally but thicker labiolingually as well. This gave the appearance that the crown was bigger than that of the upper left central.

ACCURATE ASSESSMENT OF POINT A ON LATERAL SKULL RADIOGRAPHS

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INTRODUCTION

Point A, or subspinale, was first used by Downs in 1948. He defined it as ' the deepest midline point on the premaxilla between the anterior nasal spine and prosthion '. (Prosthion is defined as the most anterior part of the alveolar portion of the premaxillary bone usually between the upper central incisors, *see Fig.* 1.)

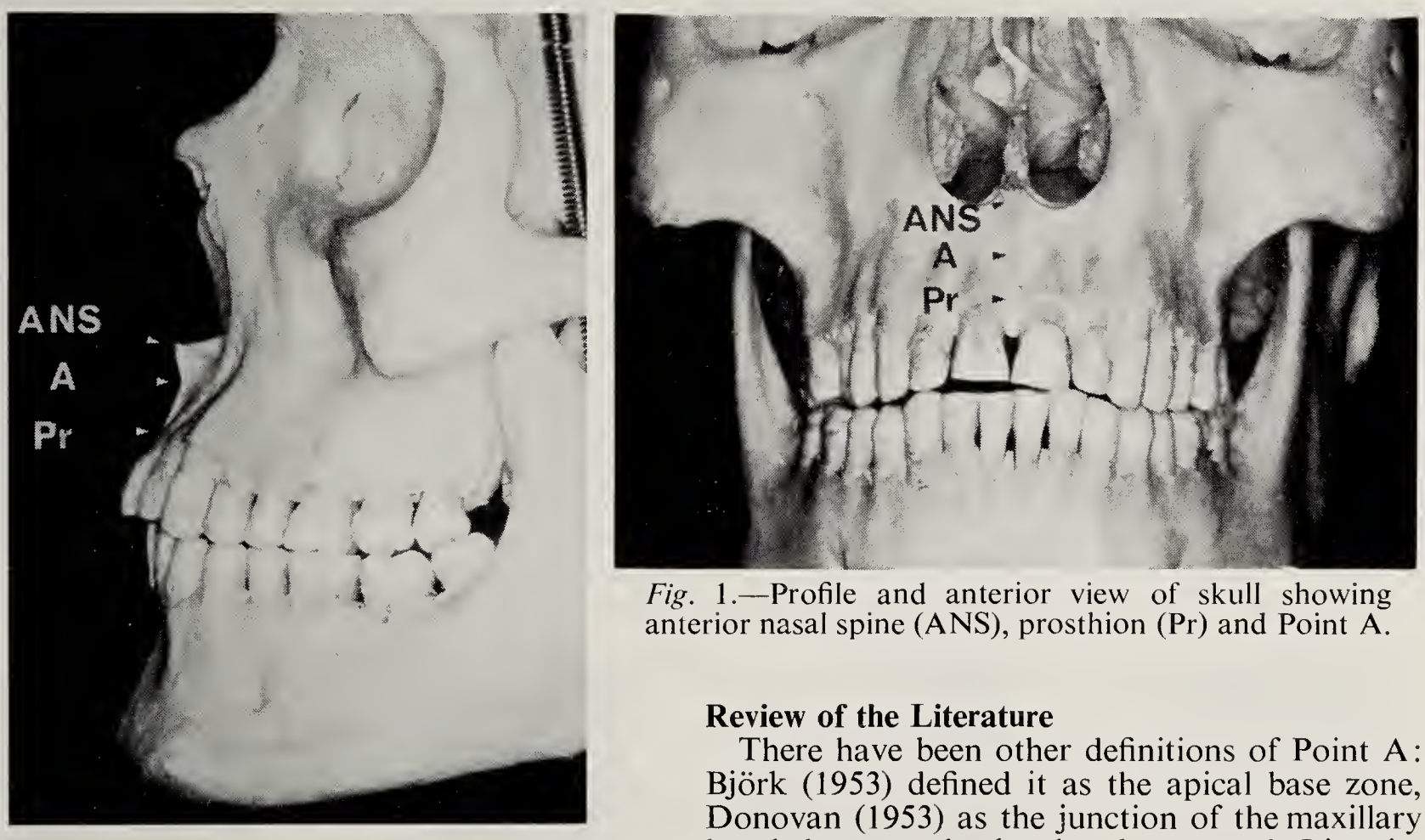


Fig. 1.—Profile and anterior view of skull showing anterior nasal spine (ANS), prosthion (Pr) and Point A.

Many investigators regard Point A as a point on the labial plate anterior to the upper central incisors. However, in the midline there is a bony septum running from the anterior nasal spine to the maxillary alveolus between the upper central incisors which is anterior to the labial plate. If point A is considered a midline point, then it is located on this septum (*Fig.* 1).

Ballard (1967) has stated that in the lateral skull radiographs the superimposition of cheek shadows onto the shadow of the midline septum has been mistakenly identified as labial plate. Similarly Point A has been erroneously placed at the junction of these shadows (*Fig.* 2).

In patients with prominent cheeks, the cheek shadows obscure the anterior bony profile and make Point A difficult to identify. However, in some patients both cheek shadows and midline septum are clearly seen (*Fig.* 3).

Review of the Literature

There have been other definitions of Point A: Björk (1953) defined it as the apical base zone, Donovan (1953) as the junction of the maxillary basal bone and alveolar bone, and Litowitz (1948) defined Point A as demarcating the alveolar process from the body of the maxilla.

Current Usage

1. The angle SNA gives an indication of maxillary prognathism. The angle ANB (SNA minus SNB) gives a measure of skeletal pattern. Ballard (1956) gives mean angles:—

SNA	81°
SNB	77·5°
Mean Difference	3·5°

Presented at the meeting held on 13 January, 1969.

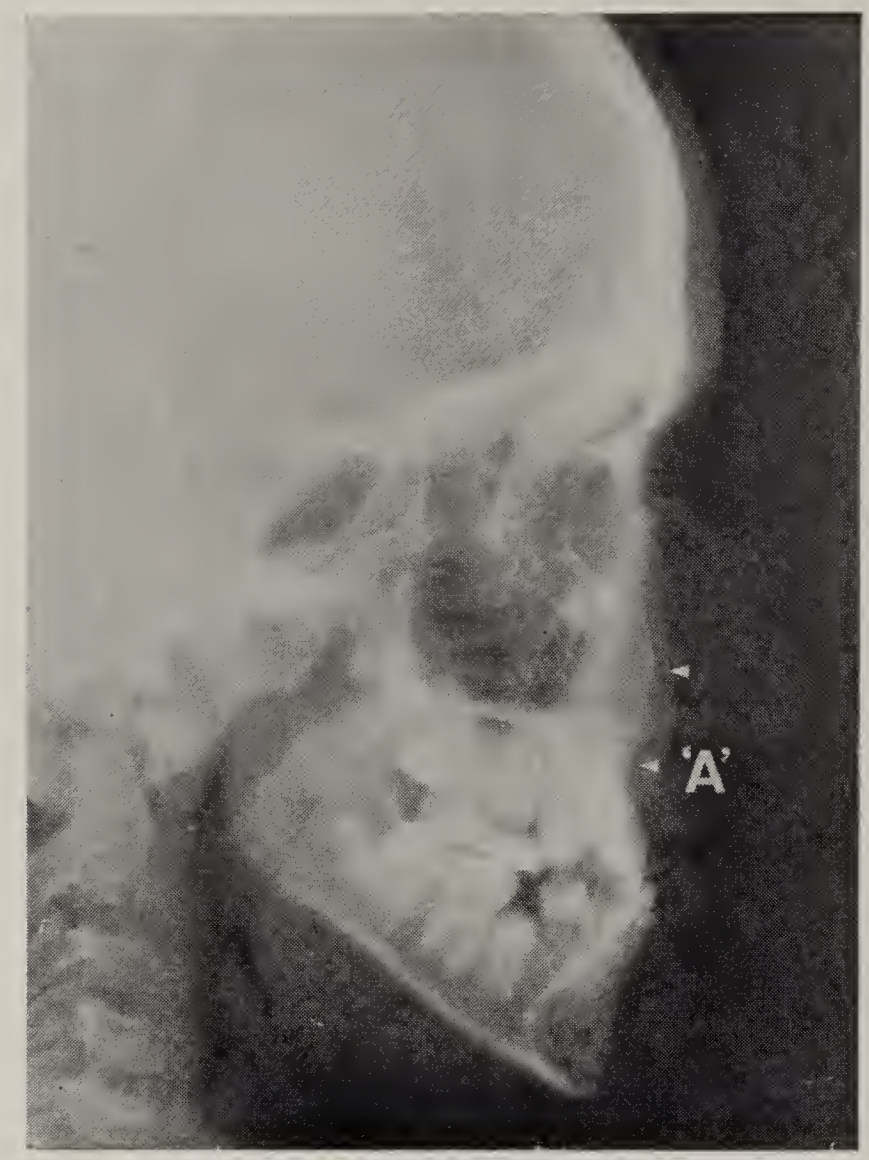


Fig. 2.—Lateral skull radiograph showing cheek shadows (arrowed) and erroneous positioning of Point A (' A ').

Fig. 3.—Lateral skull radiograph of patient in which cheek shadows and midline bony septum are clearly visible.

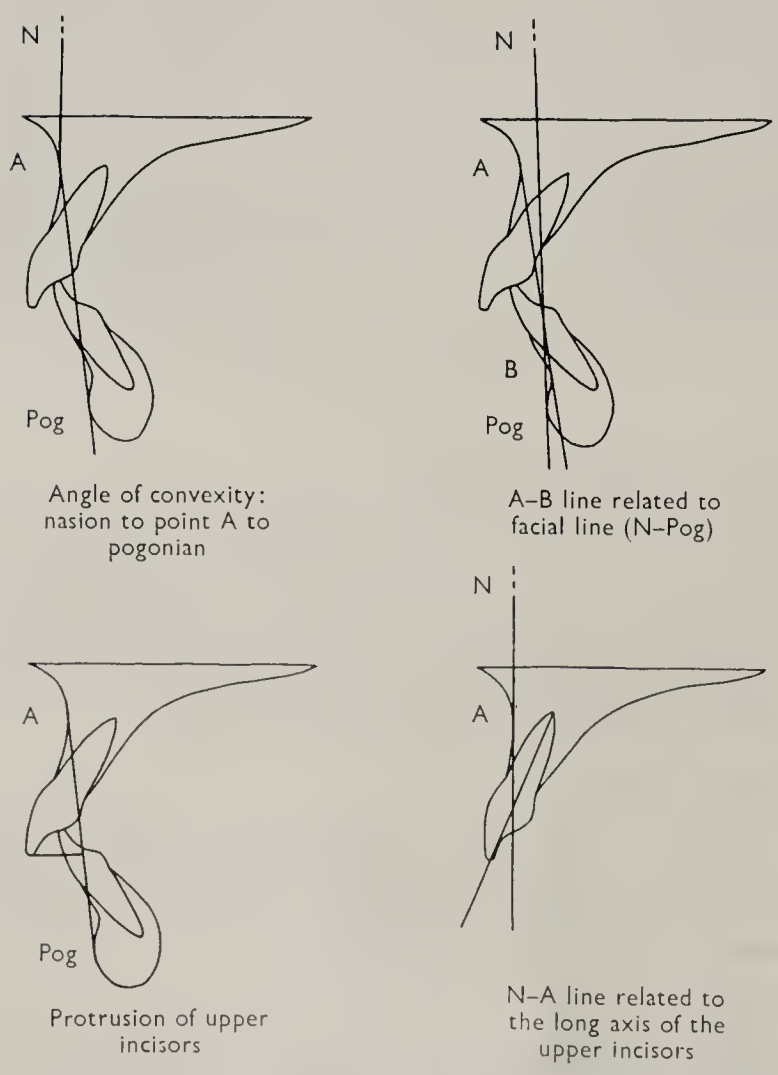


Fig. 4.—Four examples of the cephalometric usage of Point A.

2. In more complex cephalometric analyses, Point A is used in the assessment of various relationships. *Fig.* 4 shows four examples of the use of Point A.

3. Assessment of the degree of labial movement of upper incisor apices possible during orthodontic treatment necessitates accurate identification of the labial bone available.

PRESENT INVESTIGATION

An investigation was deemed justifiable to:—

1. Accurately identify the labial plate close to the upper incisor apices on lateral skull radiographs.

2. Relate this to the position of Point A. Ideally, the positioning of radio-opaque material to identify the labial plate should not subtract from the information normally obtainable from lateral skull radiographs.

Methods used

1. ' Microtrast ' was painted on the oral mucosa of the upper labial plate. This was found to be very difficult to apply both in the correct position and in sufficient concentration.

2. A piece of unsupported lead foil was found to be impossible to apply in the correct position.

3. A piece of lead foil supported on an orange stick was tried. This method was an improvement on the previous two but it was found impossible to place the piece of lead foil accurately on the labial plate. In addition, the lips were distorted.

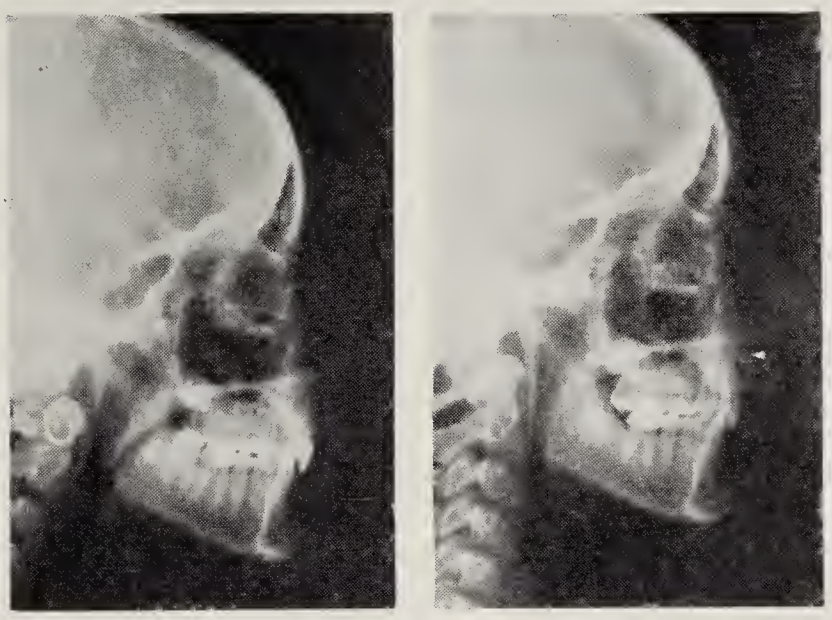
4. A forked pointer was constructed in cold-cure acrylic with a piece of 0·7 mm. soft stainless-steel wire in one of the tips (*Fig.* 5A). The pointer was constructed from a wax pattern and forked to assist in location (one fork to be placed either side of the fraenum). This wax pattern was fashioned on an upper model and curved around the alveolus. It was stepped outwards to emerge from the mouth at the lipline and then stepped downwards, the total length being approximately 9 in. (*Fig.* 5B). An investment of sufficient length was not available and a long thin cardboard box was therefore utilized.

The extreme end of the pointer was held by the patient but the patient's hand was not visible on the radiograph (*Fig.* 5C). When first tried, this method was obviously superior to the

A

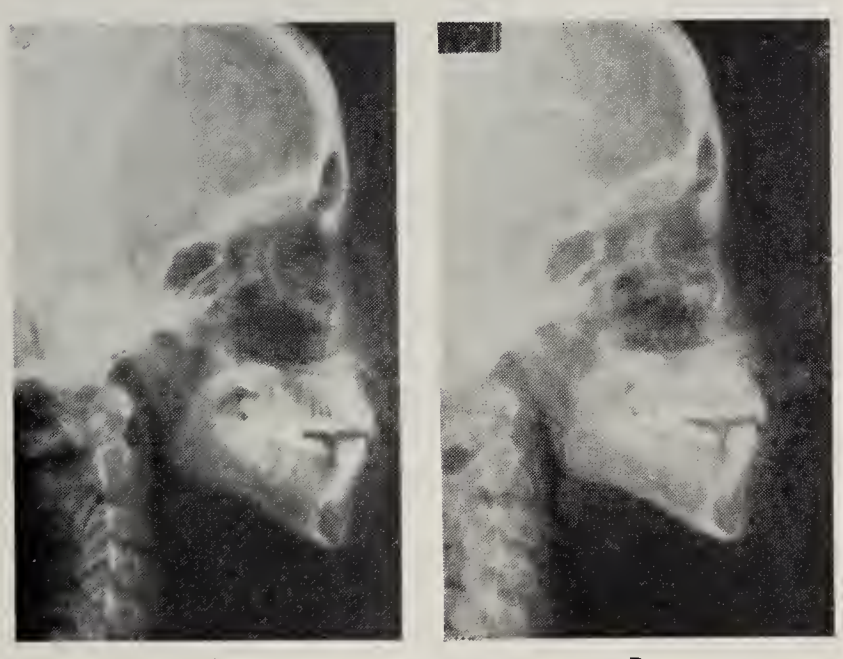
B

C



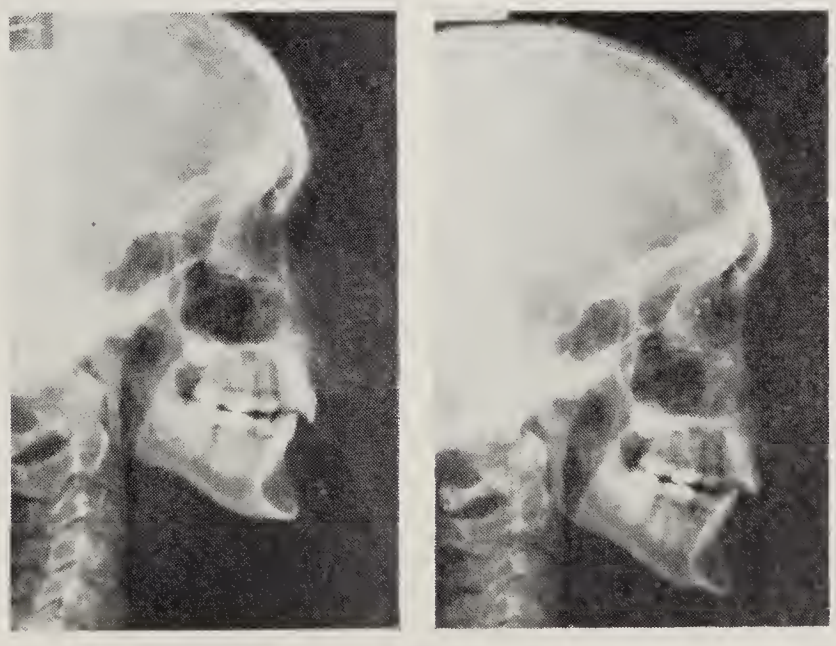
D

Fig. 5.—Illustration of the forked pointer. A, Close-up of head to show wire insert; B, Full view; C, The pointer in use; D, Pointer (arrowed) on lateral skull radiograph.



A B

Fig. 6.—Lateral skull radiographs. A, Pointer held too high; B, Positioned correctly.



A B

Fig. 7.—Lateral skull radiographs. A, Pointer held too far labially; B, Positioned correctly.

previous ones. *Fig.* 5D shows the radiographs of the first patient on whom the pointer was used.

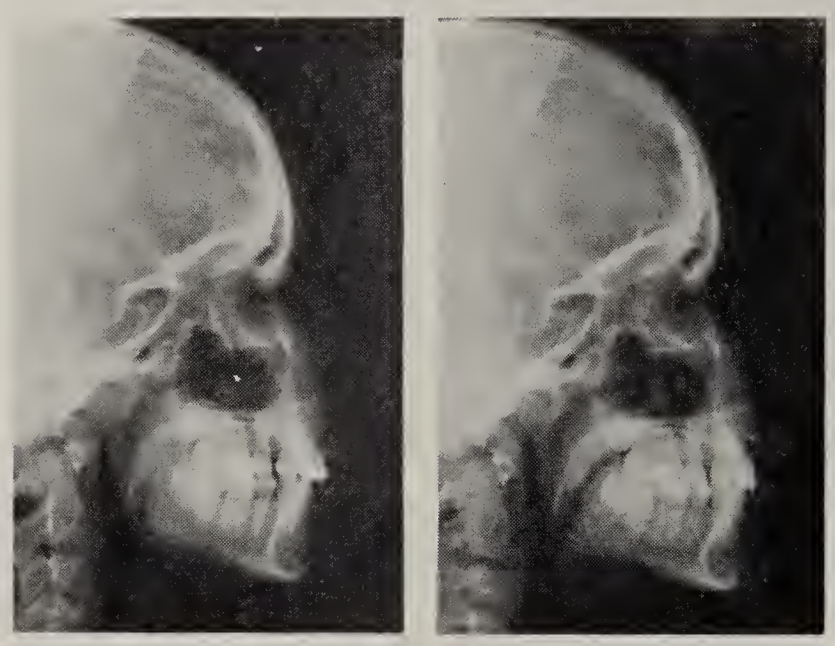
Material

First a dried skull was radiographed:—

a. Without the pointer.

b. With the pointer on the upper labial plate.

Angle SNA without the pointer was 81°. With the pointer positioned on the labial plate and



A B

Fig. 8.—Lateral skull radiographs. A, Without pointer; B, With pointer. This illustrates that there is little interference with lip position.

Table I.—Comparison of SNA Readings with SNA^2 using Pointer to identify A^2 in 9 Patients

SNA Without Pointer*	SNA^2 With Pointer†	Difference	Time Interval (months)
82	81	−1	10
82	80	−2	8
86	85	−1	8
86	85·5	−0·5	11
83	82·5	−0·5	5
76·5	76·5	0	5
86	85·5	−0·5	0
83·5	82·5	−1	15
88	87	−1	10
Average 83·67	82·83	−0·83°	8

*Average age: 13 years 9 months.
†Average age: 14 years 5 months.
Lateral skull radiographs taken at varying intervals as required by treatment progression.

taking the posterior part of the pointer as the labial plate (this point being termed ' apical alveolar point ' (A^2)) SN apical alveolar point measurement was 79°. The difference therefore was 2°. This represented a 2 mm. more posterior positioning of the labial plate as compared to Point A.

Unselected patients undergoing orthodontic treatment with original lateral skull radiographs were radiographed again, this time with the pointer in position. The lateral skull radiographs were taken at varying intervals as required by treatment progression. These radiographs were then traced.

Two possible errors in the use of the pointer were noted:—

a. If it were held too high (*Fig.* 6).

b. If it were held too far labially (*Fig.* 7).

However, the pointer interfered very little with the lip position, as demonstrated in *Fig.* 8.

Table II.—Comparison of SNA Readings in 9 Patients in Successive Lateral Skull Radiographs at Varying Intervals

SNA (Degrees)*	SNA (Degrees)†	Difference	Time Interval (months)
82·5	81	−1·5	9
73·5	74	+0·5	8
77·5	77	−0·5	8
83	85	+2	9
80	81	+1	6
79·5	79·5	0	9
79·5	80	+0·5	8
83	82	−1	10
81	81·5	+0·5	8
Average 79·94	80·1	+0·167	8·33

*Average age: 13 years 10 months.
†Average age: 14 years 6 months.

RESULTS

Table I shows that the average SNA reading using the most posterior point on the midline septum from the anterior nasal spine to maxillary alveolus as Point A in 9 patients was 83·67°. Using the pointer to identify the labial plate just lateral to the midline septum (apical alveolar point, symbol A^2), SN apical alveolar point average reading is 82·83°; a difference of 0·83°. Ideally these lateral skull radiographs should be taken on the same day. This did not seem justified and the average time interval between lateral skull radiographs was 8 months. One patient did have 2 lateral skull radiographs on the same day and there was an SNA–SN apical alveolar point difference of 0·5°.

To endeavour to eliminate any discrepancy resulting from the time interval between radiographs, comparison was made with a further group of 9 patients with lateral skull radiographs on average 8·33 months apart and of almost identical average age with the first group (*Table II*). In neither lateral skull radiograph was the pointer used. Though in no way significant

statistically, on average SNA increased by 0·16°. Thus the total SNA–SN apical alveolar point difference is on average 1° (0·83+0·16). On an SNA reading of 80° this represents approximately 1 mm.

DISCUSSION

The series of lateral skull radiographs with and without the pointer were traced by an experienced tracer though with no orthodontic training. In the radiographs using the pointer the most posterior part of the radiopaque pointer insert was taken as the apical alveolar point (A^2).

It is apparent from the results that the apical alveolar point is consistently on average 1 mm. more posterior than the assessed position of Point A. It is arguable that Point A as defined by Downs (1948), and identified on the midline septum, is *not* on the maxillary dental base. However, since most investigators place Point A on this septum, it would seem best to continue to do so. The use of a device, such as the pointer described, is indicated:—

1. If Point A is not readily identifiable, the use of the pointer will register apical alveolar point. Point A is 1 mm. anterior to this. In patients with prominent cheeks, Point A is very difficult to identify and the use of the pointer would be advantageous (*Fig.* 9).

Fig. 9.—Patient with prominent cheeks. A, Profile and full face photographs; B, Lateral skull radiographs of the same patient without (left) and with the pointer in position (right).

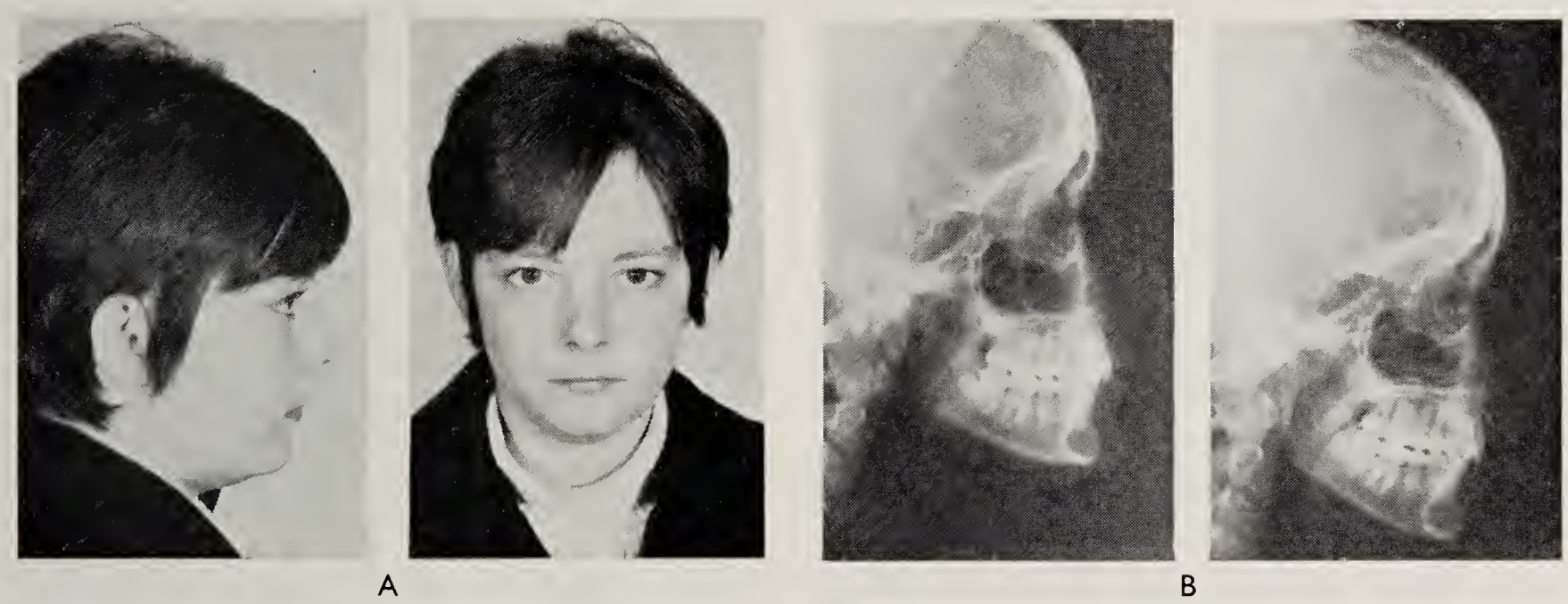


Fig. 10.—Patient with retroclined upper incisors. A, Profile and full face radiographs; B, Lateral skull radiographs of the same patient without (left) and with the pointer in position (right).

2. If accurate assessment of bone labial to upper incisor apices is required, for example, in deciding upon the amount of labial movement of upper incisor apices possible during orthodontic treatment to reduce an overjet, then the use of a pointer will facilitate this assessment.

3. In patients with retroclined upper incisors, i.e., with the apices of the upper incisors well forward, the labial plate is more easily and accurately identified (*Fig.* 10).

SUMMARY

Point A is not always easy to identify, and a forked acrylic pointer with a small stainless-steel insert in one tip is described to identify accurately the labial plate close to the upper incisor apices.

A small series of patients had lateral skull radiographs taken with and without the pointer. The point on the labial plate may be best described as 'apical alveolar point' (Symbol A^2). SNA is on average 1° greater than SNA^2. This represents approximately a 1 mm. more posterior positioning of apical alveolar point as compared to Point A.

Acknowledgements

My thanks are due to Professor C. F. Ballard, Mr. S. G. McCallin and Dr. J. R. E. Mills for permission to use lateral skull radiographs of their patients. Also to Professor C. F. Ballard for his original comment on the mistaken identification of the cheeks as maxillary alveolus and to Dr. J. R. E. Mills for advice and constructive criticism. Finally to Miss J. Jeffery for secretarial help and to the Photographic Department of the Eastman Dental Hospital for preparing the illustrations.

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DISCUSSION

Mr. J. H. Gardiner said that in his department they had recently completed a test with undergraduate students, on tracing cephalometric radiographs. Granted, the odd student would insist on putting Point N in the middle of the orbit, but the most variable point was undoubtedly found to be Point A. Not only did this point vary but, of course, all angles dependent upon this point varied too.

Mr. Morse said that he wished to make the further point that the tracer who had done the radiographs had already had her attention drawn to the possible inaccuracies. He felt that if inexperienced students had been asked to trace the radiographs the difference between points A and A^2 might have been a little greater than this.

Mr. D. Frazer found that the difficulties with the cheek shadow arose particularly when the aluminium wedge was used in conjunction with the cephalometer, and the difficulty with the cheek was not so evident when the wedge was missed out. He wondered whether this had been Mr. Morse's experience, and whether in fact one might at times deliberately omit the wedge when one was particularly keen to identify Point A accurately. He realized that this would mean leaving out soft-tissue shadow, but one could not have it both ways.

Mr. Morse said he thought Mr. Frazer had answered his own question in the last sentence. He did not feel justified in taking lateral skull radiographs except as required by treatment, and with the elimination of the aluminium wedge and therefore the soft tissues, the lateral skull radiograph would not have as much diagnostic use. However, he thought it a good point.

Dr. J. R. E. Mills said he thought Mr. Morse had made a very important point in his paper. If Point A were used to represent the labial plate of bone in conjunction with moving the apices of teeth about, it was wrong to do so.

It was a coincidence that there was a rather similar paper in the *Angle Orthodontist** recently, which appeared long after Mr. Morse's paper had been accepted for presentation to the Society. It was always interesting to have two papers more or less showing similar findings.

His impression was rather similar to Mr. Frazer's, that one had the problem of the cheeks where the radiographs were under-exposed

So far as the accuracy of the Point A was concerned, this had been calculated by quite a number of people and it was one of the more accurate points in the anteroposterior dimension. It was not very accurate vertically, and not quite as accurate as Point B. His impression was that the accuracy was somewhere over half a degree in two-thirds of cases, which put it among the better ones.

Mr. Morse said that the two radiographs he had shown, with very prominent cheeks, were, by sheer chance, the first two radiographs he had looked at on his next two patients after Professor Ballard had made his point. In fact, they were under-exposed. This was as they came.

He thought that Point A was bound to be useful because it was midline and it stuck out in front of the incisor teeth, and there was so much superimposition that it would be difficult to use any other point around the area of the maxillary alveolus.

Mr. C. P. Adams said that it was very interesting for orthodontists to know how right or wrong they were in getting the information they wanted to use for various investigations. He asked if Mr. Morse had done anything about using these two methods twice for the same material to see if he got the same result with the same method each time.

Secondly, as these were tracings and not original films, had he assessed whether the tracing introduced any error by tracing them twice, because one made one's own errors this way. Also, did Mr. Morse make these measurements himself, or allow someone else to do it because this meant the material was one degree removed from what one was trying to do.

Mr. Morse replied that he had checked the angular measurements of the tracer. He had not retraced them because he was involved. There was no second tracer and he had not known quite how to bring in a second person, who did not know what he was trying to find out, and who was not orthodontically trained.

As to whether they used Point A or not, he felt it was worthwhile making a distinction between Point A as defined by Downs and the labial plate point, A^2.

*KALAFA, J. A., and KRONMAN, J. H. (1968), *Angle Orthod.*, **38**, 225.

OBSERVATIONS ON THE GROWTH OF THE PREMAXILLA AND MAXILLA OF THE DOG WHEN AFFECTED BY A UNILATERAL CLEFT

AN EXPERIMENT IN BONE GROWTH

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THERE is already a substantial literature dealing with the growth mechanisms involved in the normal development of the facial bones. In contrast, it is only in recent times that attention has been directed to this problem in cleft lip and palate conditions. The present work has been directed towards an investigation of the facial bones of dogs affected by cleft lip and palate, with special regard to the growth changes seen in the premaxilla and maxilla. The bones were examined using macroscopic, histological, and vital staining techniques. Dogs with a unilateral cleft of the primary and secondary palates were used, so that the bones of the cleft side could be compared with those of the non-cleft side as well as with those of controls.

The subject has been treated from two aspects, namely a formal description of the parts involved and then an analysis of the findings using the material as ' Nature's experiment ' to give greater understanding of the growth of membrane bone. Particular attention has been directed towards sutural growth and the degree to which this is dependent on the activity of adjacent structures.

REVIEW OF THE LITERATURE

The use of techniques such as vital staining, histology, and cephalometrics has led to a broad understanding of the mechanisms by which the bones of the face grow in humans and animals. The processes of surface deposition and resorption and of sutural growth have been described (Brash, 1934; Moore, 1949; Baer, 1954; Scott, 1954; Björk, 1955; Pritchard, Scott, and Girgis, 1956; Enlow and Bang, 1965; Latham and Burston, 1966; and others).

Whilst the sites of growth of the facial bones are becoming more clearly understood, it is not so clear what, if anything, stimulates these bones to grow. Three main possibilities have been described. The bones may have an inherent capacity for growth (Weinmann and Sicher, 1955). Growth may be stimulated at the suture surfaces by tension exerted, in the case of the facial bones, by the nasal septum (Scott, 1954; 1967). Growth of the facial bones is a passive response to the growth of the functional matrix (Moss, 1968).

Previous work on the development of cleft affected bones almost entirely concerns humans. A number of cephalometric studies show that the face as a whole grows well in the presence of an unoperated cleft and does not differ significantly from the normal (Ortiz-Monasterio, Rebiel, Valderrama, and Cruz, 1959; Law and Fulton, 1959; Mestre, de Jesus, and Subtelny, 1960).

These findings are supported by studies on skulls affected by clefts (van Limborgh, 1964; Atherton, 1967a).

There have been many reports in the literature referring to animals with clefts. Few, however, refer in any detail to the effect on the facial bones of a cleft.

The histological appearance of the palatal shelves of cleft newborn dogs has been described by Atherton (1967c) who showed that active growth occurs at the margin of the horizontal processes at birth and that the direction of growth is affected by the tongue.

MATERIALS AND METHODS

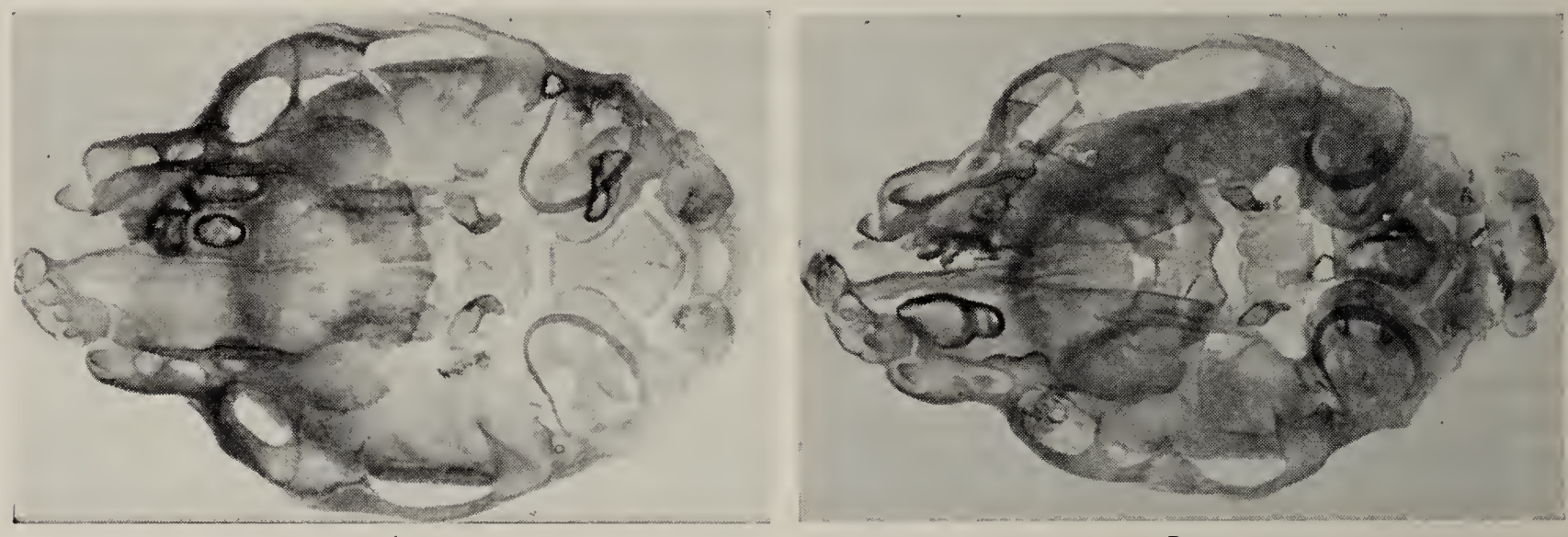
The dog specimens used for this study were referred to the author by veterinarians and dog breeders. The majority of these specimens died shortly after birth due to a failure to suckle or because they were put down. Eighteen dogs

Chapman Prize Essay, presented at the meeting held on 10 February, 1969.

were received with a unilateral cleft of the left side and 2 with a unilateral cleft of the right side. Of these dogs, 8 had an associated cleft of the secondary palate.

The head of each non-vital specimen was removed and fixed in buffered formol–saline. Five representative specimens were selected for maceration of the soft tissue and 6 for histological preparation.

The heads for maceration were skinned and the greater part of the soft tissues removed. mouth were taken at intervals during the experiment. One week before the end of the experiment the dogs were anaesthetized with nembutal and given an intraperitoneal injection of 2 per cent alizarin red S in 0·4 per cent sodium chloride at 0·5 ml. per kg. The dogs recovered from the injection well and were eating the same day. One dog was sacrificed at 6 weeks, and the other and the control sibling at 4 months. The skulls were prepared for maceration by removing the greater part of the soft tissues and heating them



A B

Fig. 1.—A, Ventral view of the head of a newborn dog (Cocker Spaniel) prepared by maceration and embedding in plastic. The specimen has a left unilateral cleft of the primary palate. One incisor is carried by the small body of the premaxilla of the cleft side. The interpremaxillary suture is patent and curves to the non-cleft side. B, Newborn dog (Beagle) with a left unilateral cleft of the primary and secondary palates. The tooth lying anterior to the maxilla of the cleft side is the precanine. Three incisors are carried by the body of the premaxilla of the cleft side. The interpremaxillary suture is patent.

They were placed in 2 per cent potassium hydroxide for a period of several weeks. The bones were stained with a weak solution of alizarin red S and embedded in plastic using the methods described by Atherton, Burston, and Gore (1964), modified by the use of xylene in place of acetone and Ward's Bioplast* for bakelite.

The specimens to be examined histologically were embedded in celloidin (low viscosity nitrocellulose) and sectioned at 24 μ using the wet method, or double-embedded in wax and cut at 10 μ. Approximately 100 sections, in series, were kept for each specimen and alternately stained with Masson's trichrome and with Ehrlich's haematoxylin and eosin.

Two of the unilateral cleft dogs and one sibling control were kept alive by feeding a dried milk preparation (Espilac) every 2 hours for the first few days and then less frequently. At 3 weeks baby cereal was given to the dogs, and at 2 months small quantities of chopped meat. Lateral head radiographs and impressions of the in a large volume of dilute potassium hydroxide (0·5 per cent) to 80° C. and leaving overnight to cool. The remaining soft tissues were removed and the skulls bleached with hydrogen peroxide and kept for study in 70 per cent alcohol.

Using a dental bur, small blocks of bone were cut from the premaxilla and maxilla for histological examination of the bone structure. Blocks were taken from the premaxilla-maxillary suture on the non-cleft side, from the same area of the cleft side, and also from the sutures between the maxilla and the nasal, frontal, and zygomatic bones. Blocks were also taken from the tuberosity of the maxilla, and across the suture between the premaxillae on each side. So that the alizarin stain would not be lost due to decalcification, each block was embedded in bakelite and then sectioned with a fine disk saw. Alternate sections were ground between glass plates to 50 μ and then stained with haematoxylin and eosin.

A further dog with a cleft of the secondary palate only was kept alive and given two injections of terramycin (25 mg. per kg.), one at 7 weeks and one a week before death at 13 weeks of age. Undecalcified sections and decalcified

*Ward's Natural Science Establishment, Inc., Rochester, 3, New York, U.S.A.

sections were prepared from the horizontal process of the maxilla of this dog.

FINDINGS

Gross Appearance of the Premaxilla and Maxilla at Birth

1. *The Premaxilla*

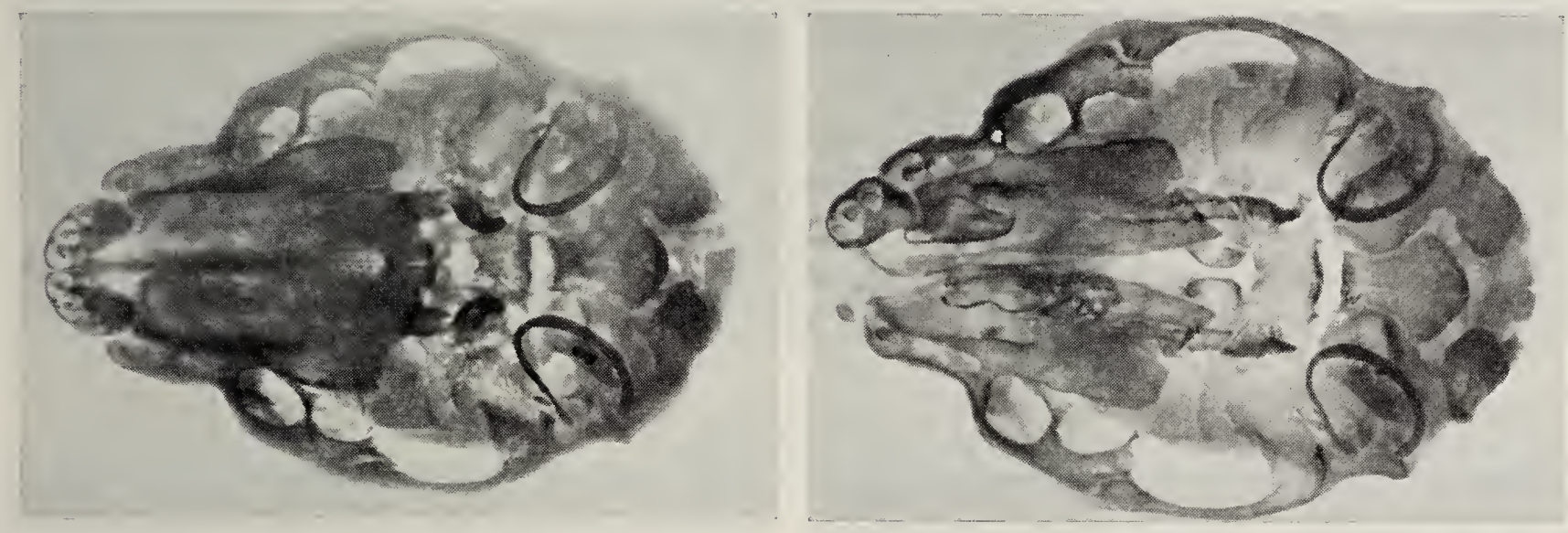
The cleft of the primary palate in the dog divides the premaxilla into a ' nasal portion ' which lies between the nasal bone and the maxilla and the main mass of the bone (referred to as the ' body ') which lies adjacent to the non-cleft premaxilla (*see Fig.* 16).

The nasal portion was present in both the older dogs (*see Fig.* 11), but appeared to be absent or not yet ossified in half of the specimens at birth. When present it resembled the nasal process of the non-cleft premaxilla.

The body of the premaxilla was greatly reduced in size and, with the premaxilla of the non-cleft side, was displaced to the non-cleft side (*Fig.* 1). The size of the cleft premaxilla was variable and in 2 out of the 5 specimens prepared by maceration it was fused to the non-cleft premaxilla with no intervening interpremaxillary suture (*Fig.* 2B). The vomerine process of the body of the premaxilla (the medial posterior extension of this bone) was curved to the non-cleft side, sometimes markedly, but was of normal size. A control specimen for comparison with the cleft ones is shown in *Fig.* 2A.

The non-cleft premaxilla was slightly smaller than normal in those specimens with the interpremaxillary suture between it and the premaxilla of the cleft side, and considerably smaller than normal in those specimens where this suture was absent (*Fig.* 2B).

The dentition was affected in the incisor region. The cleft resulted in a supernumerary tooth lying anterior to the maxilla of the cleft side and a variable number of incisors carried by the cleft premaxilla. The supernumerary tooth was invariably present and was well-formed in the shape of a small canine (*see Fig.* 16). This tooth will be referred to as the ' precanine '. The incisor compliment varied from a normal of 3 (which was the most common finding) to the possible complete absence of incisors on the cleft side. No dental abnormalities were observed on the non-cleft side.



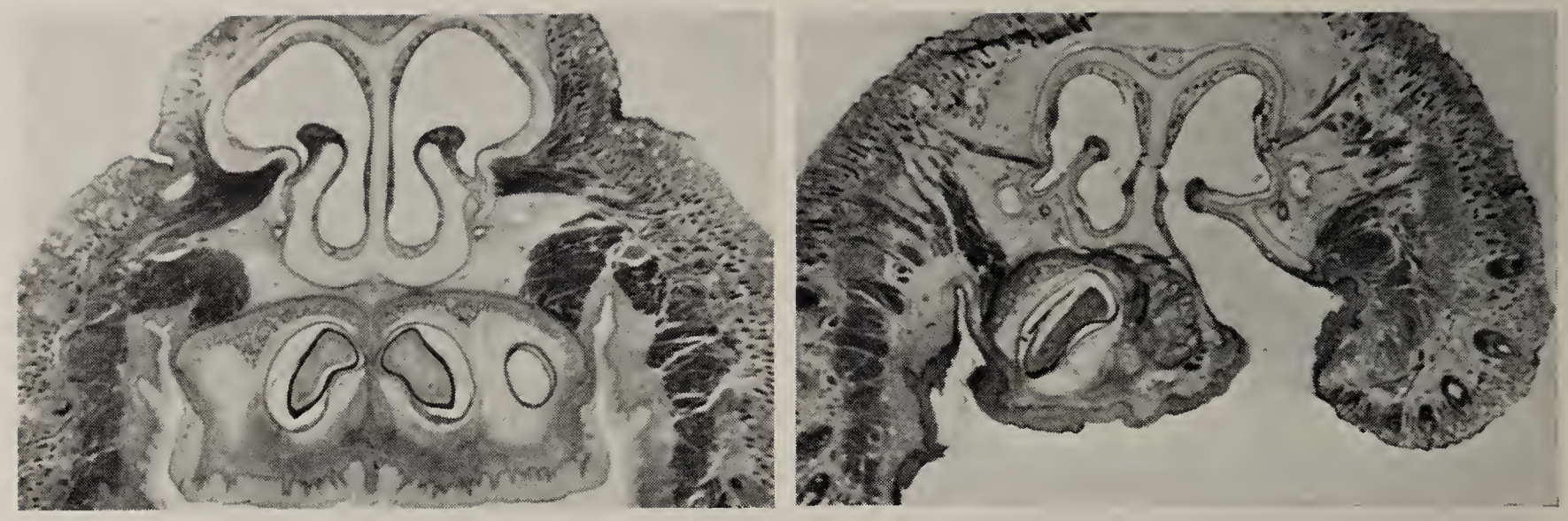
A B

Fig. 2.—A, Newborn control dog (Beagle). B, Newborn dog (Norwegian Elkhound) with a right cleft of the primary palate and a complete (right and left) cleft of the secondary palate. The interpremaxillary suture is absent. The body of the premaxilla of the cleft side is extremely small and fused to the premaxilla of the non-cleft side which itself is unusually small. Three incisor teeth are carried by the fused premaxillae. The vomerine processes of the premaxillae curve sharply towards the non-cleft side.

2. *The Maxilla*

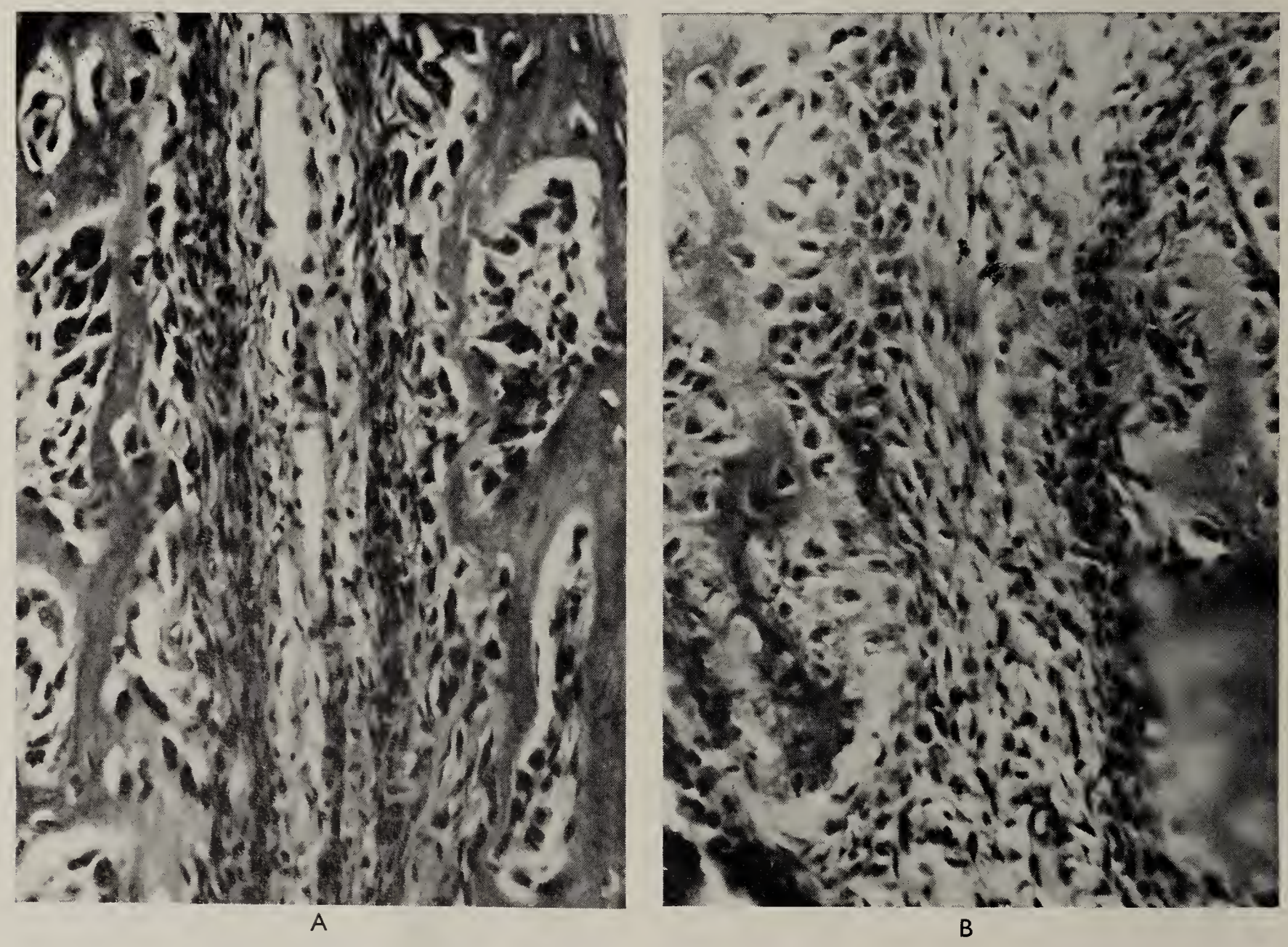
The maxillae on each side of the cleft presented a remarkable degree of similarity in size and shape when viewed from the palatal aspect. The body of the maxilla on the cleft side failed to achieve the full amount of vertical development in the canine region; a defect scarcely detectable at birth. It was orientated so that the horizontal process of the cleft side lay anterior to that of the non-cleft side (*Fig.* 1B). The difference in antero-posterior placement of the maxillae was also observed in specimens with a cleft of the primary palate only (*Fig.* 1A).

The effect of the cleft upon the growth of the horizontal process depended upon the type of cleft. When only the primary palate was cleft, the development of each horizontal process was normal (*Fig.* 1A). When the cleft also involved the secondary palate on the cleft side and the vomer articulated with the other horizontal processes (*Fig.* 1B), both horizontal processes were reduced in size, but the process articulating with the vomer was the larger. When there was a bilateral cleft of the secondary palate, then both



A B

Fig. 3.—A, Coronal section through the premaxillae and cartilaginous nasal capsule of a newborn control dog (Beagle). B, A similar section to A from a cleft specimen (Beagle) with a left unilateral cleft of the primary palate. The ventral parietal cartilage is divided and its lateral part lies beneath the mucous membrane of the cleft side. The base of the nasal septum and the bodies of the premaxilla are displaced to the non-cleft side. There is an associated ' twisting ' of the nasal capsule. The premaxilla of the non-cleft side shows a normal bone pattern. The premaxilla of the cleft side is being resorbed on its lateral surface which is covered by the mucous membrane lining the cleft. Masson. (×3·6.)



A B

Fig. 4.—Photomicrographs of the anterior part of the interpremaxillary suture of a control newborn dog (A) and a cleft sibling (B). The appearance is indicative of osteogenesis on each bone surface. The darkly stained, fully calcified woven bone is lined by a layer of paler osteoid tissue. Against this surface lie the large osteoblasts. A loose cellular zone lies in the central part of the suture. H. and E. (×300.)

horizontal processes were equally affected and were smaller than normal (*Fig.* 2B).

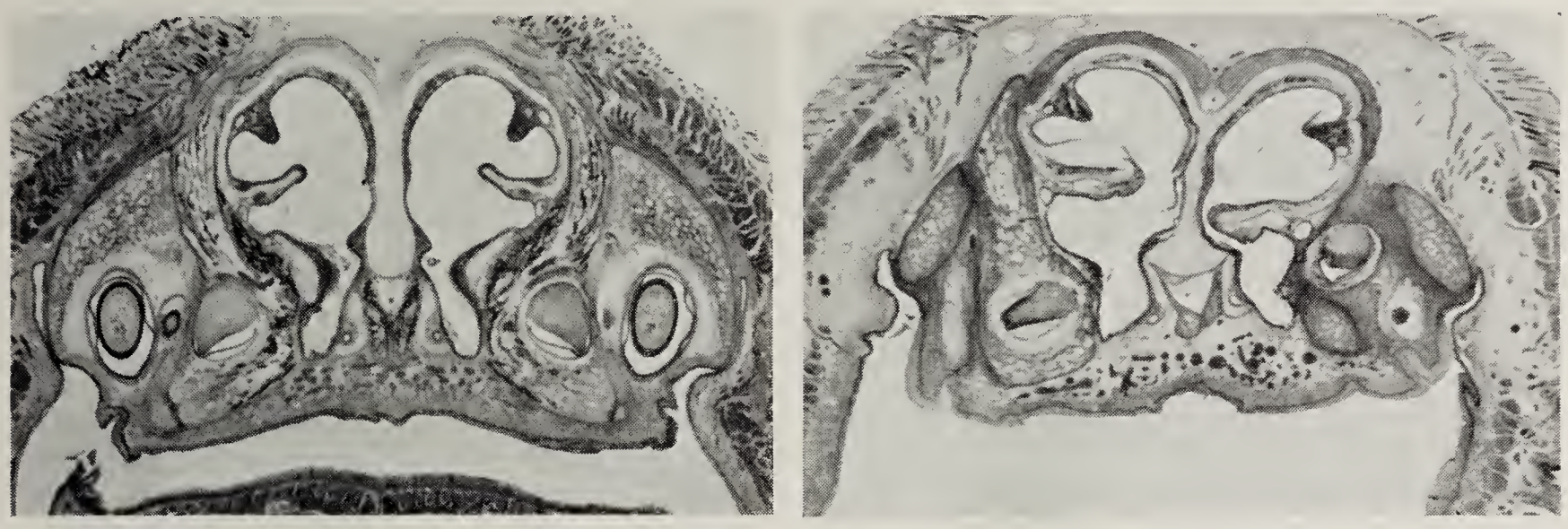
Histological Observations at Birth

The premaxilla and maxilla were examined histologically to determine their relationship to neighbouring structures and the pattern of bone apposition and resorption. Areas of surface apposition were indicated by the presence of numerous large basophilic osteoblasts, several layers thick, lying against the surface of the bone which was composed of lightly stained woven bone. The bone surface in areas of most rapid growth presented pointed trabeculae from which large bundles of osteogenic fibres radiated outwards. Areas of resorption were shown by the presence of multinucleated giant cells and associated Howship's lacunae and by the abrupt margin of the bone surface.

1. *The Premaxilla*

The control premaxillae lay symmetrically placed beneath the anterior part of the cartilaginous nasal capsule with the 'interpremaxillary' suture directly beneath the nasal septum (*Fig.* 3A). The histological appearance of the coronal sections indicated that the control premaxilla was growing rapidly on the ventrolateral aspect and less rapidly on the dorsal surface and intermaxillary suture. The bone was also growing rapidly when seen in sagittal section in an anterior direction at the alveolar margin, at the premaxilla-maxilla suture, and at the posterior border of the vomerine process. Resorption was seen around the crypts of the erupting incisors and above the anterior part of the anterior paraseptal processes.

The premaxillae of the cleft specimen were displaced to the non-cleft side. On the cleft side a large part of the premaxilla was missing and the remaining part of the body and alveolus reduced in size. The bone pattern differed from the controls on the lateral aspect of the cleft body. This area (*Fig.* 3B) showed no lateral growth and areas of resorption were seen,



A B

Fig. 5.—Coronal section through the anterior part of the maxilla and premaxilla of a control specimen (A) and a cleft specimen (B). In B the precanine separates the anterior aspect of the maxilla of the cleft side from the cartilaginous nasal capsule and the nasal fossa. The morphology of the woven bone of the maxilla is similar on each side. (×2.)

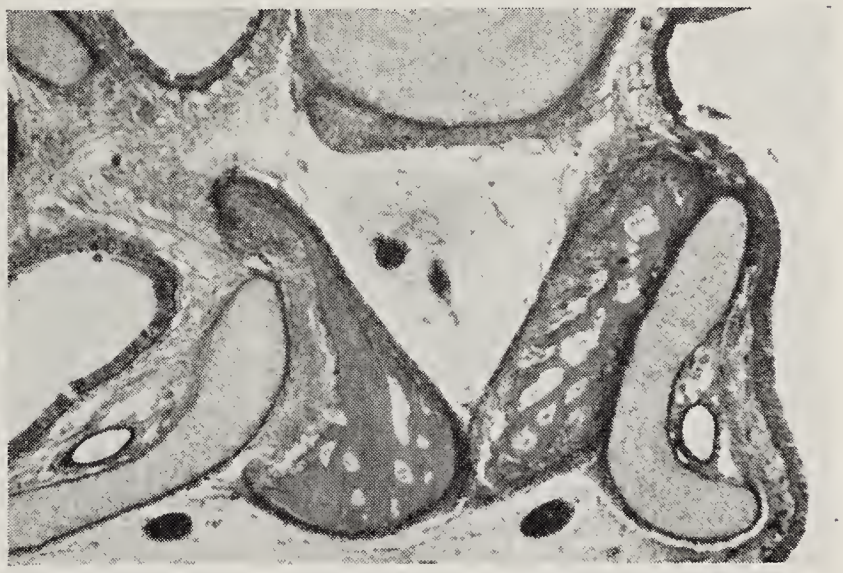
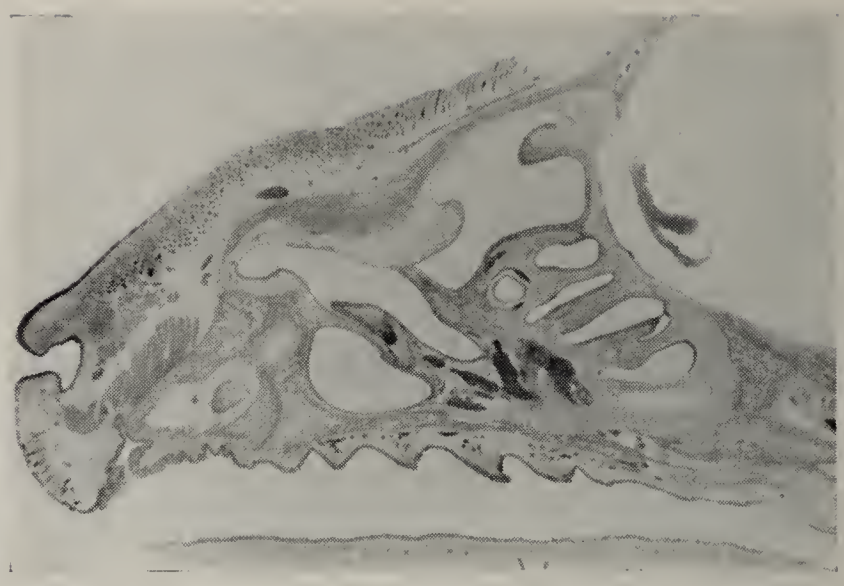


Fig. 6.—Photomicrograph of the vomerine processes of the premaxillae of the same specimen as in *Fig.* 5B. Cleft side on right of photograph. There is a difference in the morphology of these bones. The vomerine process of the cleft side is undergoing rapid apposition on its medial wall and resorption of the lateral wall. The vomerine process of the non-cleft side is more bulbous and shows little apposition on the medial surface and more rapid apposition on the lateral surface. (×30.)

particularly where the bone came near the mucous membrane lining the cleft. The interpremaxillary suture of the cleft specimens appeared normal in all the specimens prepared histologically with active apposition occurring on each bone surface (*Fig.* 4A, B).

There was a difference in the morphology of the vomerine process of the non-cleft and the

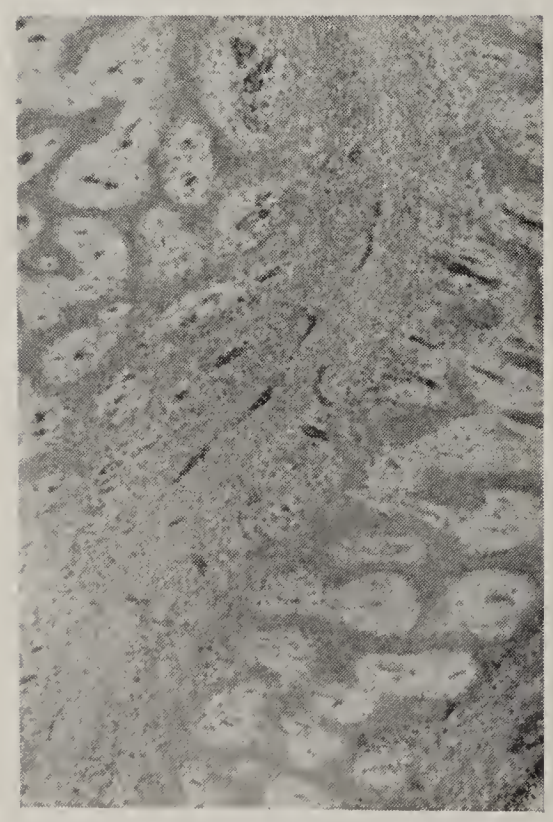
A



B

C

Fig. 7.—Sagittal sections through the maxilla and premaxilla of newborn dogs. The morphology of the maxilla is similar in all three specimens, despite the absence of the premaxilla in C. H. and E. (×1·8.) A, Control specimen (Beagle). The section passes through the maxilla-premaxilla suture. B, Non-cleft side of cleft specimen (Beagle) with a unilateral cleft of the primary palate. C, Cleft side of cleft specimen. The premaxilla is missing and the precanine lies anterior to the maxilla.



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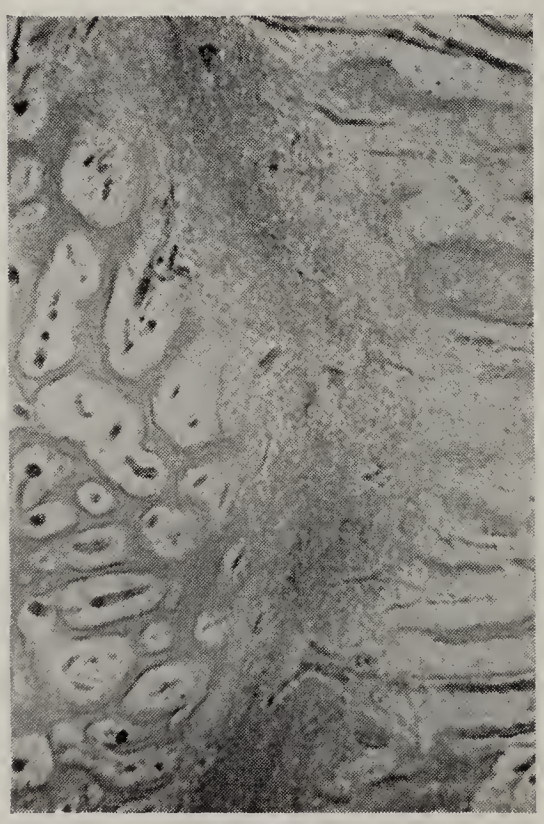


B

C

Fig. 8.—A, Control specimen. Photomicrograph of the maxilla-premaxilla suture seen in *Fig*. 7A with the maxilla on the right of the suture and the premaxilla on the left. B, Photomicrograph of the non-cleft side of cleft specimen. Close up of *Fig*. 7B. The appearance of this suture is similar to A above. C, Photomicrograph of the cleft side of cleft specimen. Close up of *Fig*. 7C. The precanine lies on the left of the photograph. The maxilla, on the right of the photograph, is composed of elongated bone trabeculae orientated anteriorly. The surface of the maxilla is covered by an osteogenic periosteum which is similar to the maxillary half of the intact suture seen in A and B above. The form of this membrane is not influenced by the presence of the precanine. H. and E. (×43.)

cleft sides. The vomerine process of the cleft side showed active apposition on the medial surface and resorption on the lateral surface (*Fig.* 6). The vomerine process of the non-cleft side was more bulbous and showed little activity on the medial surface and apposition on the lateral surface.

The histological structure of the premaxilla of the non-cleft side resembled that of control specimens.

The cartilage of the nasal capsule was normal except for the immediate area of the cleft (*Fig.* 3B). Here all parts of the capsule were present and of normal histological structure but there was some distortion. The ventral parietal cartilage was divided near its junction with the nasal septum and lay displaced beneath the mucous membrane of the lateral side of the cleft. The base of the nasal septum was displaced to the cleft side and there was also some distortion of the upper part of the septum and dorsal parietal cartilage which is best described as being twisted towards the non-cleft side.

2. *The Maxilla*

The body of the maxilla on the cleft side differed from that of the control in the position of its anterior part, which, because of the absence of the greater part of the premaxilla, was separated from the nasal capsule and nasal cavity by the precanine tooth (*Fig.* 5B). The anterior part of the maxilla deserves special mention. It showed a remarkable capacity for growth despite the absence of the premaxilla. The sites of surface apposition and the loose-woven bone pattern were identical on the cleft and non-cleft sides when examined in coronal (*Fig.* 5B) and in sagittal section (*Figs.* 7B, 8B, C). On the non-cleft side the suture between the maxilla and the premaxilla consisted of a mass of osteoblasts lining each bone surface only faintly separated by a central area of loose cellular tissue. On the cleft side the suture was replaced by a layer of periosteum which was comparable in cellularity and, judging by the morphology of the bone spicules, in its capacity to deposit bone with the layer of osteoblasts on the maxillary side of the maxilla-premaxilla suture. The precanine which lay anterior to this layer of periosteum did not appear to influence the periosteum, for the appearance of this membrane and bone was similar over the whole area (*Figs.* 7C, 8C).

Posterior to the canine region no difference was observed between the body of the maxilla on the cleft side and that of the non-cleft side except for the horizontal processes of these bones when the cleft affected the secondary palate. The sutures between the maxilla and the nasal, frontal, zygomatic, and palatine bones were examined and found to be similar to those of the controls. The tuberosity region was also similar on the cleft side to the same area of non-cleft and controls.

The horizontal processes of the control specimens met at the midpalatal suture (*Fig.* 9A). The medial margins of the bones thickened near the midline to form a wide, flat surface at the suture. Apposition of bone was observed on the ventral (inferior) surface and more actively on the medial surface where there was a thick layer of osteoblasts adjacent to a layer of pale staining bone orientated at right angles to the suture surface. There were a number of multinucleated giant cells on the dorsal (superior) surface indicating that this surface was undergoing resorption.

The cleft horizontal process of the maxilla in unilateral clefts (Atherton, 1967c) at birth was usually placed horizontally above the tongue (*Fig.* 9B). Rapid apposition of bone was seen at the rounded median margin of the cleft horizontal process where there was a thick layer of osteoblasts. Resorption was seen on its dorsal surface and apposition on the ventral surface. The growth at the cleft horizontal process was therefore proceeding in a medial and ventral direction. This pattern was still present at 3 months (*Fig.* 9C) and was confirmed by the position of the tetracycline-stained bone which lay on the dorsolateral aspect of the horizontal process. It was presumed that the medial and ventral growth of the process (accompanied by resorption on the dorsal surface) had carried the stained part of the bone from its original site of deposition on the medial and ventral surfaces to the dorsolateral aspect of the bone.

The Postnatal Growth of the Premaxilla and Maxilla

Both the unilateral-cleft dogs kept alive for vital staining of the bones were brachycephalic (i.e., they had short wide heads). The experiment was concluded on the first dog, a Bulldog, at $6\frac{1}{2}$ weeks and on the second, a female Boxer, at $3\frac{1}{2}$ months. The dogs were killed at this age so that at the time of death the bones would be growing rapidly and yet a large part of the total growth would have been accomplished.

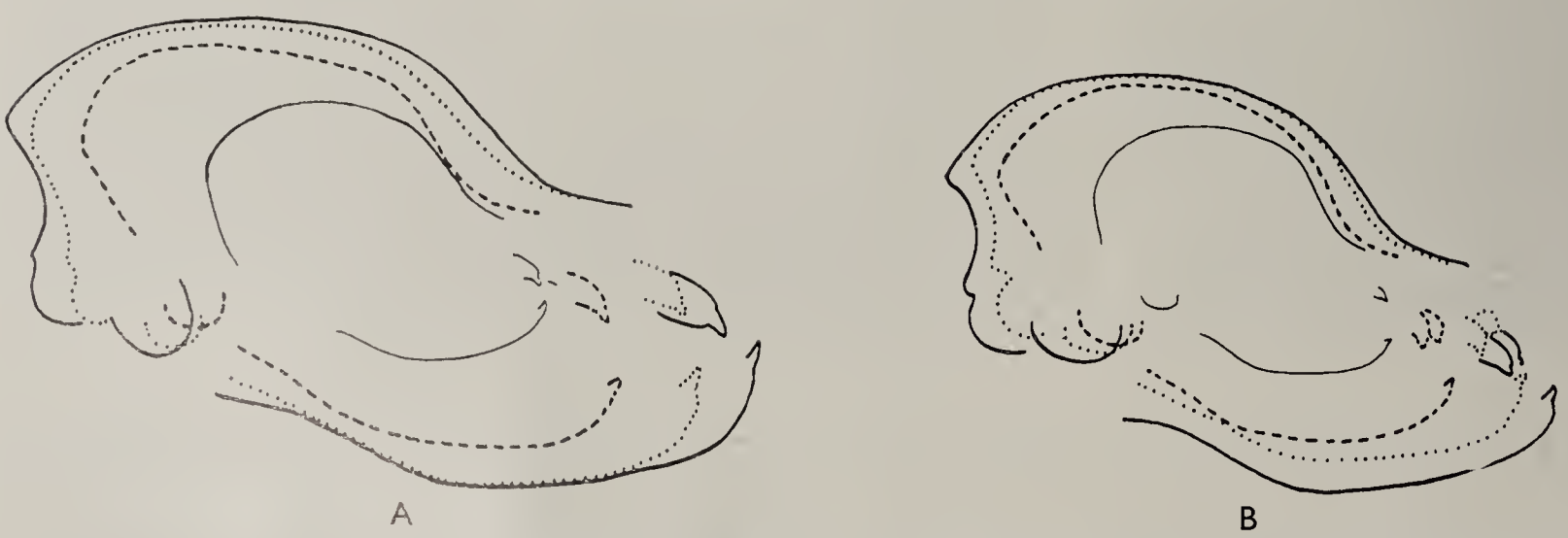
The cleft dogs showed similar features during the period of study and therefore only the Boxer will be described. Rather surprisingly, the proportions of the face of the cleft Boxer did not appear to change with growth and, apart from the immediate area of the cleft, superficially resembled the control male dog which was kept with it. The lateral radiographs (*Fig.* 10) confirmed this impression. They were not taken under the same stringent conditions that are used for human cephalometric radiographs and therefore the facial pattern was not measured on these radiographs. The radiographs did not show any major disturbance to the growth of the face of the cleft dog. Study models of the palate taken at intervals following birth show

A

B

C

Fig. 9.—A, Section through the midpalatal suture of a newborn control dog. An osteogenic periosteum lines the ventral (inferior) surface, which extends onto the medial surface of the horizontal process, where it forms one half of the midpalatal suture. The medial surface of each horizontal process is composed of pale staining bone spicules orientated at right angles to the suture. Osteoclasts are present on the dorsal (superior) surface which is undergoing resorption. Masson. (×16.) B, Horizontal process of a newborn dog affected by a cleft of the primary and secondary palate. The ventral surface is covered by an osteogenic periosteum which extends onto the medial surface of the process. The osteoblasts which line these surfaces are more numerous on the medial surface. Osteoclasts are present on the dorsal surface. (×18.) C, Horizontal process of a 3-month-old dog affected by a cleft of the secondary palate. The ventral and medial surfaces are lined by osteogenic periosteum and the superior surface by osteoclasts. The dog was given injections of terramycin 7 weeks and 1 week before death. When viewed in ultraviolet light fluorescing bone is seen on the dorsolateral part of the process, as indicated. The fluorescing bone is present in this situation because the medial and ventral growth of the process accompanied by resorption of its dorsal surface has carried the fluorescing area towards the dorsolateral aspect of the process. (×9.)



A B

Fig. 10.—Tracings taken from lateral radiographs of control Boxer (A) and cleft sibling (B) at intervals from birth to 104 days. The ages at which radiograph were taken were: birth—continuous line; 39 days—broken line; 70 days—dotted line; 104 days—continuous line.

that the growth of the palate was not disturbed by the cleft. Both palates almost doubled in length during the period of study and became relatively narrower than at birth.

The general development of the cleft skull was good. It was smaller than the control skull; this was considered to be because the cleft female Boxer was smaller than the male control and not because of a direct effect of the cleft upon the growth of the face. The skulls drawn from photographs are shown in *Figs.* 12 and 13, with the areas of alizarin stain indicated by dots.

The premaxilla of the cleft specimen on the cleft side was divided into a nasal portion which was similar to the nasal process of the non-cleft side, and a body lying adjacent to the non-cleft premaxilla.

Undecalcified sections taken through the body of the premaxilla of the cleft side (*Fig.* 14B) showed that there was bone apposition on the dorsal surface but the lateral, inferior, and medial surfaces were almost inactive. The interior of the body of the cleft premaxilla was composed of dense, compact bone except for those parts where new bone had been laid down in association with the eruption of the incisors.

The precanine tooth had erupted and, with a small mass of supporting alveolar bone and the crypt of the permanent precanine, lay at the anterior margin of the maxilla on the cleft side.

The maxilla on the cleft side of the cleft specimen differed from that of the opposite side in position and form. It was slightly rotated anterolaterally in the same manner as the newborn specimens. The canine and first premolar region on the cleft side failed to reach the same level as the rest of the alveolus (*Fig.* 11). This lack of development was more noticeable than at birth. Posterior to the second premolar the bone was well developed and appeared normal.

The areas of bone apposition on the maxilla shown by the presence of pink alizarin stain were similar on each side of the cleft specimen and on the control (*Figs.* 12, 13).

Histological examination of the undecalcified sections confirmed that the maxilla on the cleft side was growing well. The bone structure of the maxilla-zygomatic suture and the tuberosity regions was similar on each side. The anterior surface of the maxilla of the cleft side showed apposition of bone in an anterior direction which was comparable with that of the non-cleft side (*Fig.* 15).

DISCUSSION

It was anticipated when this study was designed that the cleft of the primary palate passed between the premaxilla and the maxilla in dogs. It would appear, however, that this is only partly correct for in several animals, if not all, one part of the premaxilla ossifies on the anterior side of the cleft and one or more parts on the posterior side. Albrecht (1879) describes how in the horse the premaxilla is divided into a body (the mesognathion) and a nasal portion (the endognathion) which carries the precanine. In the mouse there is a large nasal portion, but there is no precanine (Reed and Snell, 1931). In the dog, these findings

Fig. 11.—Frontal view of the skull of a 6-week-old Bulldog prepared by maceration of the soft tissues. The canine region of the left side fails to attain the general level of occlusion. The nasal process of the cleft premaxilla can be seen between the nasal bone and maxilla on the left side. The precanine tooth has been lost in preparation. The alveolar bone associated with the precanine lies anterior to the maxilla of the cleft side.

show the nasal portion as a structure separate from the precanine and which may be absent. The precanine is, however, invariably present and after birth develops an alveolus. The cleft therefore in several mammals directly affects the structure of the premaxilla and incisor teeth but leaves the maxilla intact. This relationship of the cleft to the two bones may account for the difference in the severity with which these bones are affected by a cleft and for the different growth patterns they exhibit.

The Premaxilla

The premaxilla was affected by a cleft more severely than the maxilla. A large part of the bone lying between the ' nasal ' portion and the ' body ' was missing and the body itself, greatly

reduced in size, showed a distinctly abnormal pattern of growth. It continued to grow at the interpremaxillary suture but the lateral surface, which bordered the cleft, failed to grow and was resorptive in parts. The body thus appeared to be growing at the interpremaxillary suture only to be resorbed on its lateral aspect (*Fig.* 3B).

The premaxillae of the cleft specimens also differed from normal in the region of the vomerine process. The vomerine processes of each side show a pattern of resorption and apposition which appears to indicate a lateral movement or shift of the vomerine processes towards the non-cleft side (*Fig.* 6). This shift of the vomerine

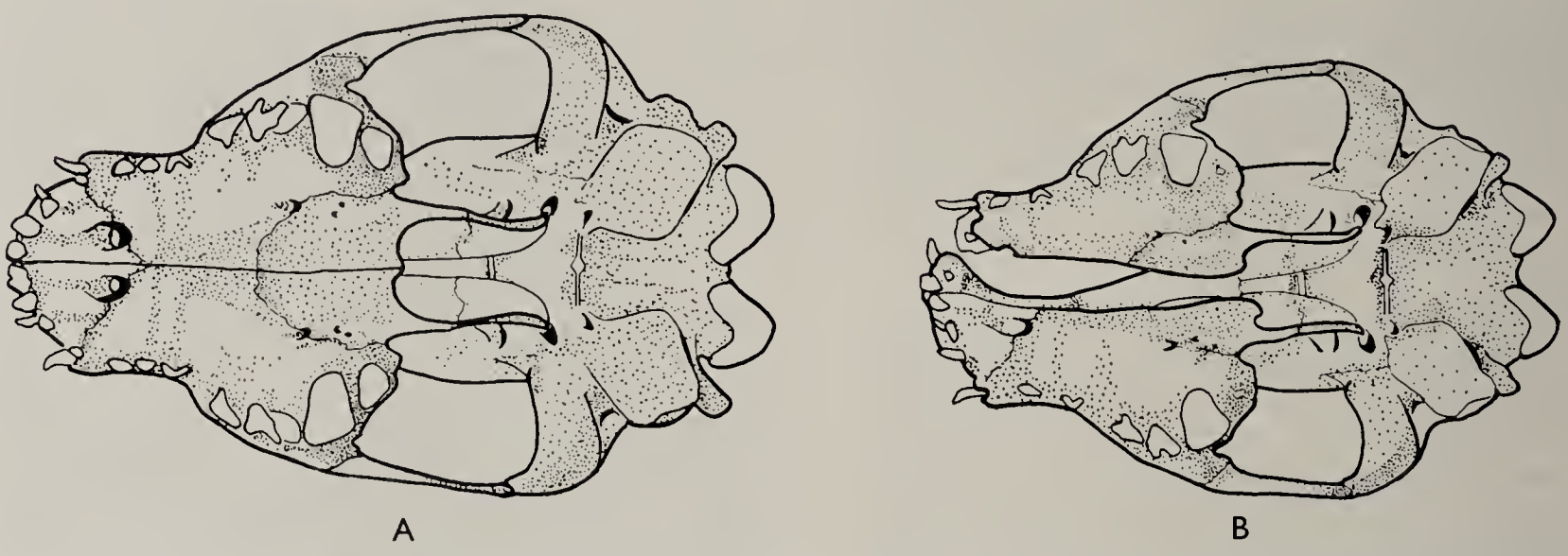


Fig. 12.—Drawings made from photographs of the palatal view of a $3\frac{1}{4}$-month-old control Boxer (A) and cleft sibling (B). The sites of deposition of alizarin red S are indicated by dotted shading.

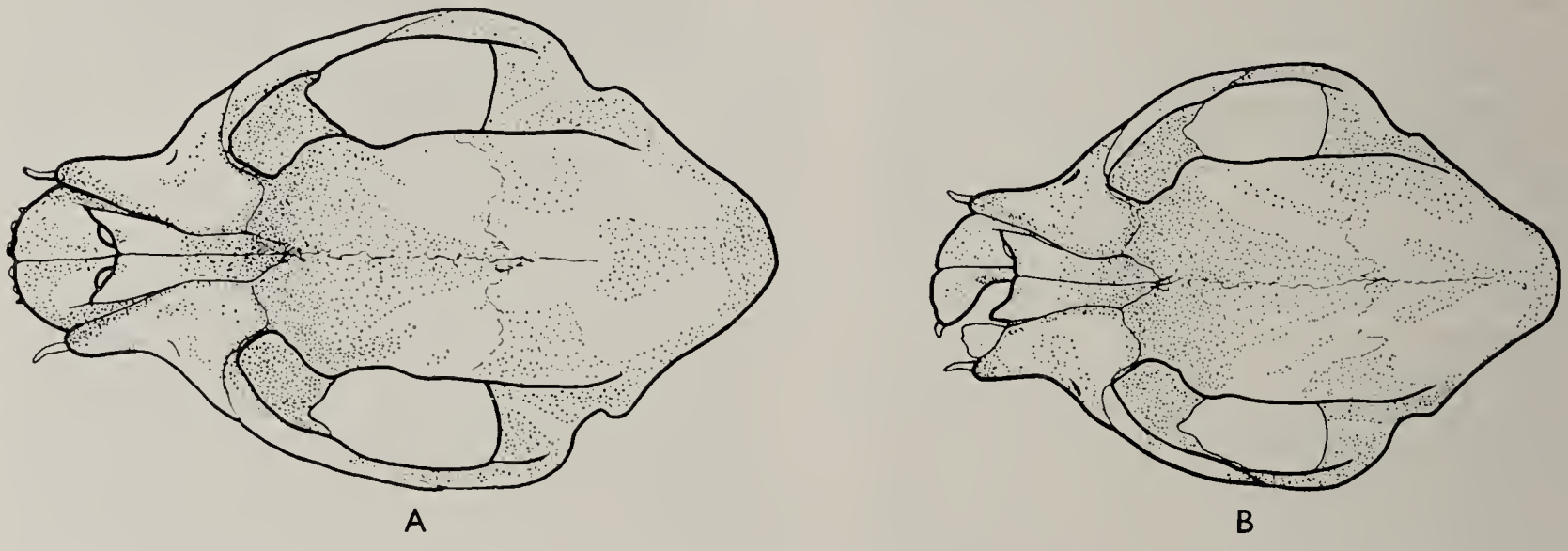


Fig. 13.—Drawings made from photographs of the dorsal view of $3\frac{1}{2}$-month old control Boxer (A) and cleft sibling (B). The sites of deposition of alizarin red S are indicated by dotted shading.

Stark (1954) has shown that this area of the human embryo (shortly after cleft formation) is deficient in mesoderm. It would be interesting to know if the growth failure seen on the lateral aspect of the bone is due to a persistent shortage of tissue in the region of the cleft, or to the growth of the bone being restricted by a deficiency of other tissues such as the mucous membrane. Resorption occurs in the areas where the bone comes into close proximity with the mucous membrane and it therefore seems possible that its growth is being restricted by this. If the mucous membrane is restricting the growth of the premaxilla an operation which closes the primary palate may create a bridge into which the lateral aspect of the cleft premaxilla could grow.

process may be explained by a consideration of the growth pattern in this region. The posterior part of the vomerine process lies in the midline and articulates at a rapidly growing suture with the vomer. The forward growth occurring at the posterior margin of the vomerine process carries this part of the bone forward. In the case of cleft specimens the premaxillary bodies are displaced laterally (as in the human) and the vomerine processes curve laterally to conform with this displacement. Therefore, as the vomerine process moves forward in cleft specimens, it must also move laterally.

The premaxilla of the non-cleft side was slightly smaller than normal. Possibly this was due to a small reduction in bone apposition

occurring at the interpremaxillary suture. Some reduction in the activity of this suture might be anticipated if the theory of a separating mechanism being necessary for growth to occur at a suture is accepted, for the cleft of a primary palate prevents any possibility of tension being applied across this suture. No histological difference was observed between the interpremaxillary suture of the cleft and the control specimens, but in two macerated specimens the suture was absent altogether and in these two specimens both the non-cleft and the cleft premaxilla were smaller than in the other cleft specimens. Why the suture should not be patent is not clear. It is possible that the effect of the cleft was more severe in these two specimens than in the majority.

The Maxilla

Although the maxilla is separated by a cleft of the primary palate from the body of the premaxilla it still retains substantial powers of growth. At birth the maxilla on the cleft side is remarkably similar to that of the opposite side and to the normal. In this respect the effect of a cleft upon the growth of the maxilla is similar to that reported in humans (van Limborgh, 1964; Atherton, 1967a, b). This remarkable capacity of the facial bones to grow is a considerable encouragement to clinicians who have to deal with cleft lip and palate conditions. The slight failure of the anterior region to attain the normal degree of vertical development can be detected only with difficulty. By 4 months this deformity in the boxer is obvious but still not marked. Histological examination of the sutures showed that growth at the sutures around the maxilla of the cleft side was active and could not be distinguished from normal at the ages studied.

It is suggested that there are factors which mitigate the effect of a cleft upon the growth of the maxilla:—

1. The cleft passes anterior to the maxilla so that no part of this bone is missing (unlike the premaxilla).

2. The cartilage of the nasal capsule is normal except for the immediate area of the cleft and, at least until the time of its ossification after birth, gives support to the bones of the face.

The observation that the deformity is more apparent at 4 months than at birth tends to support this view; for it is only after birth that the lateral walls of the cartilaginous nasal capsule begin to ossify. Also the part of the maxilla which is well-supported by the capsule (from the second premolar posteriorly) is apparently normal.

3. The precanine tooth and the nasal process of the premaxilla on the maxillary side of the cleft support the anterior aspect of the maxilla and thus reduce the deformity produced by the absence of a large part of the premaxillary bone.

4. Although there is no suture between the maxilla of the cleft side and the premaxilla, the layer of periosteum which replaces this suture in the cleft specimen is remarkably osteogenic. It resembles, in structure, the maxillary half of the premaxilla-maxilla suture. The bone formation at the anterior border of the cleft maxilla is also similar to that of the non-cleft maxilla (*Fig.* 8B, C). Thus, although the cleft divides the suture (or more correctly the suture fails to form at the anterior border of the maxilla) the periosteum replacing it retains the capacity to grow well. At 4 months the morphology of the bone at the anterior border of the maxilla is also similar on each side of the cleft (*Fig.* 15) and the deposition of alizarin stain equally intense.

The Cleft as an Experiment on Suture Growth

The cleft performs an experiment when it separates the anterior surface of the maxilla from the premaxilla. It completely removes from one side of a suture the influence of the adjacent surface. It has been noted that when this happens the periosteum which remains on the maxilla resembles the maxillary half of the intact suture (*Fig.* 8). The underlying bone also appears similar to the non-cleft side not only histologically but also in gross anatomical form (*Fig.* 7). It is clear therefore that a substantial part of the growth occurring at the anterior surface of the maxilla is independent of the premaxilla, and also of any separating tension.

A similar situation occurs at the midpalatal suture, which at birth is an active growth site. When this suture fails to form, as occurs when a cleft involves the secondary palate, the horizontal process of the maxilla (and palatine bone) grow at the medial margin. This rounded margin of the horizontal process differs in form from the normal which is thickened, but the histological picture (*Fig.* 9B) is indicative of growth. The ability of this margin to grow is also shown by the use of tetracycline stain in a specimen killed at 3 months (*Fig.* 9C).

The midpalatal suture and the suture between the anterior border of the maxilla and the premaxilla each consist of two independently growing layers of periosteum in proximity which are capable of growth when one is absent. It should also be noted that the periosteum which replaces the intact suture at these surfaces grows in an organized and correctly orientated manner and at a rate peculiar to that surface (*Fig.* 8). It cannot be proved from these findings, however, that the total growth at a suture surface is achieved without the influence of the adjacent bone and tissues. A separating tension as suggested by Scott (1954) or an intact matrix may therefore be necessary for a suture to achieve its full growth potential.

The maxilla, premaxilla, and midpalatal sutures are similar to the other sutures between

Fig. 14.—Undecalcified sections of the interpremaxillary sutures and adjacent parts of the premaxillae of $3\frac{1}{2}$-month-old control Boxer (A) and cleft sibling (B). The small size of the cleft premaxilla has made it possible to cut through the full thickness of this bone. A, There is apposition of bone on the dorsal surface, indicated by the woven appearance of the bone and the presence of alizarin stain (on sections not stained with H. and E.). There are small areas of apposition on either side of the interpremaxillary suture. There is a mass of newly formed woven bone around the incisors which is presumed to be associated with the eruption of these teeth. This woven bone extends to involve the ventral surface. B, The appearance of the bone of the non-cleft side is similar to A. There is some apposition of bone on the medial part of the dorsal surface of the cleft side, but the lateral and ventral surfaces are largely inactive. The bone on each side of the interpremaxillary suture appears similar to that of the control section, although this suture inclines towards the cleft. The interior of the cleft premaxilla is composed of compact unstained bone except for areas of woven bone associated with tooth eruption. (Low power.)

Fig. 15.—A, Undecalcified section through the anterior surface of the maxilla and the nasal process of the premaxilla of the non-cleft side of the cleft Boxer. The maxilla contains the canine root. The maxilla shows rapid apposition of woven bone on the free anterior surface and on the surface which articulates with the premaxilla. B, The anterior surface of the maxilla of the cleft side. The precanine and its alveolus were removed from this surface. The general morphology of the bone is similar to A; there is apposition of woven bone in an anterior direction despite the absence of the premaxilla. (Low power.)

membrane bones. It is therefore deduced that at other sutures the greater part of the growth which takes place on one surface is independent of that of the opposing surface. A suture may be regarded as two layers of periosteum which happen to be in contact with each other.

SUMMARY

Twenty newborn dogs with a unilateral cleft of the primary palate were examined for abnormalities in the growth of the premaxilla and maxilla. The heads of 5 dogs were macerated and 6 serial sectioned and stained. One dog was kept alive for $6\frac{1}{2}$ weeks and one for 4 months. Both these dogs were given an intraperitoneal injection of alizarin red S one week before death. The heads were macerated and undecalcified sections prepared from blocks cut from the premaxillae and maxillae.

It was found that the cleft divided the premaxilla into a ' body ' which lay adjacent to the non-cleft premaxilla and a ' nasal portion ' (sometimes absent) which lay between the nasal and maxillary bones. The dentition was divided into a normal or reduced compliment of incisor teeth, which were carried by the premaxillary body and a ' precanine ' which lay anterior to the anterior border of the maxilla.

The body of the cleft premaxilla was greatly reduced in size. The majority of specimens showed normal growth at the interpremaxillary suture but showed resorption on the lateral aspect of the cleft premaxilla body. The vomerine processes of both premaxillae appeared to be shifting laterally towards the non-cleft side. This movement was considered to be an adaptive remodelling of bone designed to move it in the direction of the laterally displaced bodies of the bones.

The maxilla of the cleft side at birth closely resembled that of the non-cleft side and the normal. The slight failure in the vertical development of its anterior part was more obvious by the age of 4 months. That the maxilla developed as well as it did when it was separated from the premaxilla was attributed to the following factors:—

1. The cleft lies anterior to the maxilla and leaves its structure intact.
2. The maxilla is supported by the cartilaginous nasal capsule at least until the time of birth.
3. The precanine to some extent compensates for the absence of a large part of the premaxilla.
4. The capacity of the maxilla for growth at its anterior surface which is independent of the absence of the premaxilla.

It is deduced from the behaviour of the anterior border of the maxilla on the cleft side and from the medial margin of the cleft horizontal process that the greater part of the growth which takes place on one suture surface is independent of the opposing surface.

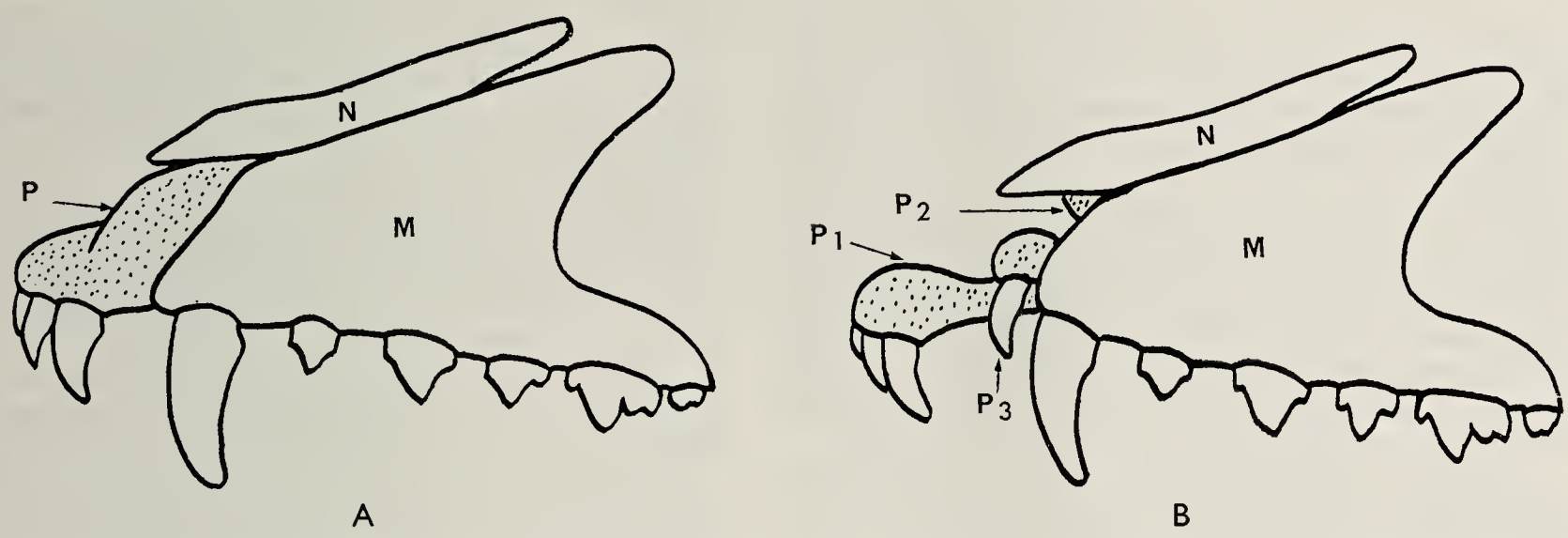


Fig. 16.—Diagrams of the facial bones of the dog from the lateral aspect. A, Non-cleft control specimen, B, Cleft specimen; N, nasal bone; M, maxilla; P, premaxilla; P_1, body of cleft premaxilla; P_2, nasal portion of cleft premaxilla; P_3, precanine and alveolar bone.

Acknowledgements

Thanks are due to Miss K. Maclean and Miss L. Leeuwangh for secretarial help, to Mr. S. Bailie, Miss J. Homer, and Mr. K. Walters for the photography, and to Mrs. P. Harris and Mrs. A. Smith for technical assistance.

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DISCUSSION

Dr. J. R. E. Mills commented that Dr. Atherton had mentioned that clefts in dogs were very much more common on the left than on the right side. This was the same as in human beings. He wondered whether Dr. Atherton had any comments to make on that.

With regard to the presence of precanine teeth, he did not much like that name, but in comparative anatomy it was accepted that the most anterior tooth in the maxilla was always the canine. Yet in Dr. Atherton's dogs and also in human beings, the tooth immediately behind the cleft was not necessarily a canine. It was very often a lateral incisor or some malformed representative of the lateral incisor.

It seemed to him that the explanation was that they were talking loosely when they talked about the premaxilla because the cleft occurred long before there was a maxilla or premaxilla, and the cleft was between the mesodermal processes and not between bones. He thought that this was important, that the cleft occurred essentially between mesodermal processes, and the relationship which it might bear to the later developing tooth was secondary. It might go to either side of the lateral incisor or it might go ' through ' it and produce two teeth. In human beings, it was more common for the tooth to be mesial to the cleft, unlike the situation in dogs.

A further important point was the question of growth. Professor Scott believed that growth of the maxilla was brought about by two factors, of which one very important one was growth of the cartilaginous nasal septum, carrying the face with it. In cleft palate patients, it seemed that in an unoperated adult, the maxilla bore the normal relationship to the rest of the face although there was a big gap between it and the rest of the face, and no attachment of the small segment to the nasal septum. Apparently in dogs, the anterior part of the maxillary segment was out of occlusion but so was the anterior part of the premaxilla. Research was reported from Liverpool by Drs. Burston and Latham on embryological cleft material, in which they showed the reduced growth at the maxillary sutures on the side detached from the nasal septum. He wondered whether Dr. Atherton found the same thing in dogs.

Dr. Atherton said that the matter of increased frequency on the left side was very interesting but he had no suggestion as to why it should be so. The incidence reported in dogs (18:2) certainly seemed to bear out strongly the statistics on humans.

He called it the precanine in the convention of the older anatomists who used the effect of the cleft on the dentition to substantiate arguments as to whether the premaxilla was separate from the maxilla in man or whether it was a single bone. By convention it had been called the precanine but it could well be an incisor tooth, and as Butler had suggested, there seemed to be spheres of influence so that, in animals, one got a molariform region and a canineiform region. It seemed possible that the tooth distal to the cleft was an incisor, but lying immediately in the region of the canine proper, it took canineiform morphology.

With regard to the growth of the maxillary bone, he found that the maxilla grew remarkably well in humans who were not operated on. The findings of the paper to a large extent supported that. Postnatally, there was in the dog some reduced growth of the maxilla but what was striking was the large amount of growth that actually took place.

Mr. P. G. Sullivan asked whether Dr. Atherton thought it possible, using his vital staining technique, to make any assumption about rate of growth on either side of the cleft.

Dr. Atherton said he thought it would be possible. The vital staining technique, particularly using ultraviolet methods, was very sensitive.

The President then thanked Dr. Atherton for his paper and presented him with the Chapman Prize.

METHODS OF REPOSITIONING THE MISPLACED CANINE

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INTRODUCTION

WHEN the presence of a misplaced canine has been established on clinical and radiographic evidence, a decision will have to be made whether to leave well alone, to remove the tooth surgically, or to uncover surgically and move the canine into the line of the arch by orthodontic means. A further method is the surgical repositioning of the unerupted canine which deals with its alinement in one operation but, as yet, the long-term results using this technique have not been established.

The purpose of this paper is to discuss the radiographic assessment of the misplaced canine, and should this be favourable, the subsequent surgical intervention, prior to orthodontic repositioning. These methods, while not original, may be of interest to those who have not previously used them.

THE ASSESSMENT OF THE UNERUPTED CANINE

This has been well covered in papers by Hitchin (1951, 1956), Hartley (1955), and Kettle (1957), and is dependent on the clinical and radiographic findings.

Clinical Assessment

This involves palpation of the region both buccally and lingually, and testing for mobility or loss of vitality of the adjacent teeth. The angulation of the lateral incisors and condition of the deciduous predecessors should also be noted.

Radiographic Assessment

This is a controversial topic and I only propose to outline the method conceived by Professor Ballard and described by Broadway and Gould (1960). This involves the taking of standardized postero-anterior and lateral skull radiographs, so providing 2 views at right angles to each other. Information may then be obtained in all planes and the canines accurately localized. In addition, an intra-oral periapical film is also required to provide details of the canine and its surrounding structures. This view will also show any dilaceration of the canine root or increase in the size of the follicle. As the canine lies in close proximity to the incisor roots, any resorption of these teeth will also be revealed. However, when resorption of the deciduous canine root is evident this may be regarded as a favourable indication that the canine is erupting close to its deciduous predecessor (Mills, 1967).

Fig. 1 illustrates how information may be obtained from the two skull views.

a. The postero-anterior view gives information in the vertical and lateral planes. Both the crown and apex of the canine should be assessed separately, and in this case the canines are upright with their crowns and apices lying in a normal position lateral to the second incisor roots. In the vertical plane the unerupted canines are seen to be at the same height.

b. The lateral skull view provides information in the horizontal or anteroposterior plane and also the vertical plane. This view shows the canines to be just overlapping the roots of the incisors, so indicating that in the anteroposterior plane the canines are in the line of the arch. If they were behind the roots of the incisors, it would indicate that they were palatal, and conversely if they were lying in front of the incisor roots they would be buccally placed. This relationship is, of course, influenced by the height of the canine and the inclination of the incisors.

The necessity for taking an additional intra-oral radiograph is illustrated in the case shown in *Fig.* 2.

In *Fig.* 2A, the postero-anterior and lateral skull views show the unerupted left maxillary canine to be in an unfavourable position, with its crown placed behind the upper left central incisor close to the midline. The upper right canine had erupted palatally in an upright position behind the peg-shaped upper right lateral incisor. From these two films, which have the vertical dimension in common, it may be seen that the two canines are at different heights. The postero-anterior view indicates the side to

Presented at the meeting held on 10 February, 1969.

which each belongs, and then looking at the lateral skull it is possible to identify and assess each canine with certainty. However, neither of these skull views indicated the extent of destruction to the root of the upper left central incisor although it might be suspected, having localized the crown of the left canine to correspond with the position of the incisor root.

related to the mesial surface of the upper left central incisor root. When the crown is displaced towards the midline past the distal of the central incisor root, the prognosis for repositioning the canine in its correct place in the arch must be considered poor.

The lateral skull view shows both the canines to be placed behind the roots of the incisors, so

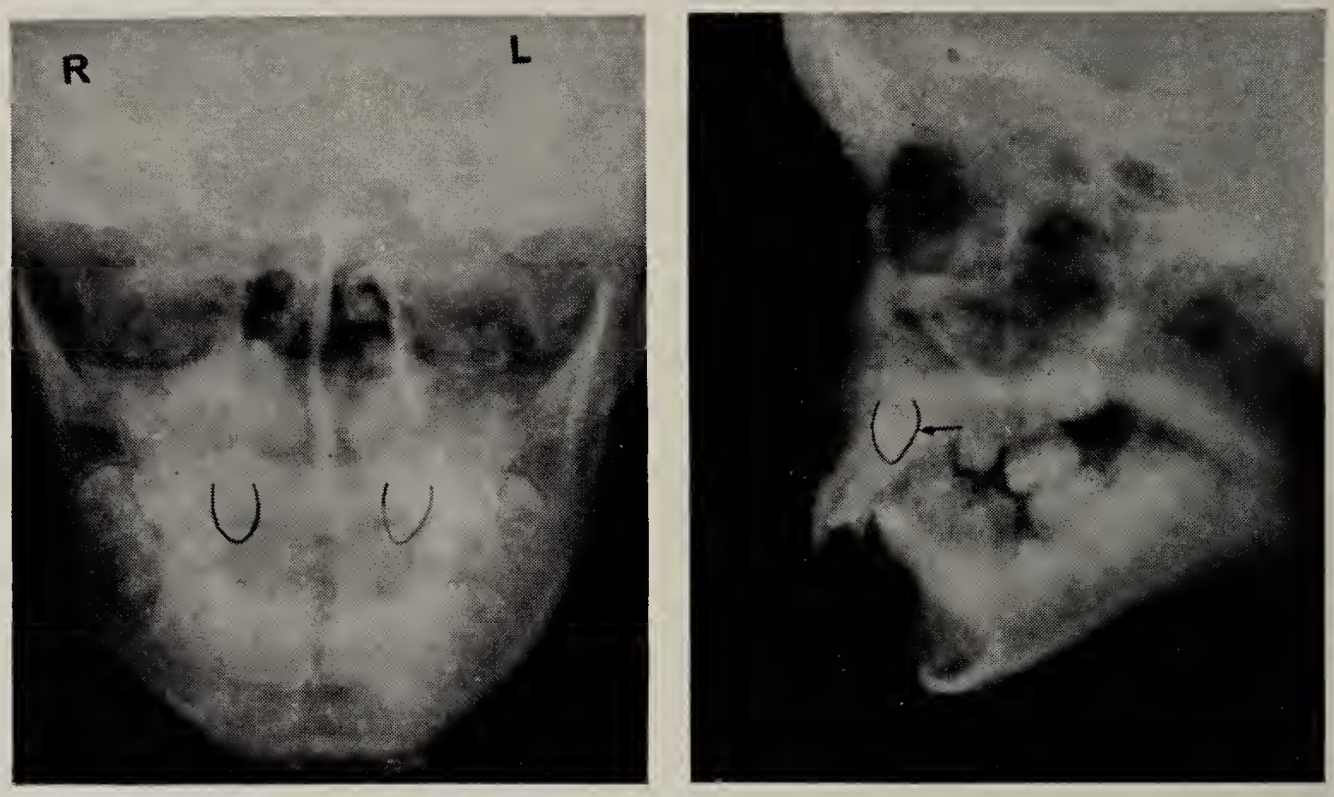


Fig. 1.--Postero-anterior and lateral skull radiographs of a 10-year-old child with the unerupted maxillary canines developing in a normal position.

In *Fig.* 2B, the intra-oral view prior to surgical removal of the unerupted left canine indicates that there has been some resorption of the upper left central incisor root. The postoperative film, 4 months later, shows the extent of oblique resorption of the root of the central incisor. Incidentally this case presented was a girl of 16 years whose main complaint was pain and looseness of her upper left front tooth. Clinically the left incisor was very mobile, tender to percussion but gave a vital response to the electric pulp tester.

Following surgical removal of the left canine, the upper left central incisor retained its vitality and became firm.

Fig. 3 shows the position of the unerupted maxillary canines in a 17-year-old boy, indicating the right canine to be in a favourable position whereas the left canine was in an unfavourable position. This was subsequently confirmed by surgical exposure of these teeth.

In *Fig.* 3A, the postero-anterior view shows the crown of the upper right permanent canine to be displaced towards the midline as far as the distal of the upper right central incisor root, the apex being in the line of the arch. The upper left canine is at a higher level than the upper right canine with its apex approximately in the line of the arch. The crown, however, is displaced towards the midline to such an extent that it is indicating that both are palatally placed, the right canine being at a lower level. Therefore, the radiographic assessment including intra-oral films, indicated that the upper right canine was in a favourable position for bringing it into the line of the arch, whereas the upper left canine was unfavourable. This was confirmed clinically following surgical uncovering (*Fig.* 3B).

Thus the accurate radiographic assessment of the unerupted canine is a prerequisite to subsequent treatment planning. Although the use of skull films for localization is not an infallible method, it does provide more information than any of the intra-oral radiographic methods.

Table I.—Skin Exposure to Radiographs

View	*Dosage*
Lateral skull	0·08 r
Postero-anterior skull	0·13 r
Intra-oral apical	0·39 r
Standard occlusal	0·6 r
Vertical occlusal	1·2 r

The dosage for skull films is low (*Table I*) and for orthodontic diagnosis a lateral skull is usually a routine radiograph—an additional postero-anterior film therefore only increasing the dosage by a small amount. The total dosage from postero-anterior, lateral skull, and intra-oral films will be seen to equal exactly that of a

standard occlusal, and is half the dosage of a vertex occlusal.

Having assessed the unerupted canine to be in a favourable position—namely the root is reasonably straight, the apex in the line of the arch, and the crown in such a position that surgical misplaced canine is not indicated, however favourable the prognosis.

As the patient is frequently in the late teens, he, or especially she, must be fully aware of the inconvenience of wearing orthodontic appliances. Finally, it is, of course, advisable to ensure at

A

B

Fig. 2.—A, Shows the $\underline{|3}$ to be in an unfavourable position but does not indicate the extent of resorption of the $\underline{|1}$ root. B, Pre- and postoperative intra-oral radiographs to show the extent of resorption to the root of $\underline{|1}$.

exposure does not endanger the adjacent teeth—then orthodontic repositioning of the canine should be considered. However, there must be adequate space into which to move the canine. Should there be a good contact between the first premolar and lateral incisor, and both are sound teeth, the heroic repositioning of a the outset that the unerupted canine is a sound tooth before extracting another tooth to provide adequate space, or letting the patient embark on a lengthy course of treatment which is unlikely to succeed. Once the decision has been made to reposition the unerupted canine, surgical intervention will almost certainly be necessary.

THE SURGICAL ASPECT

This depends on the position of the canine and is basically of two types. Firstly, if the canine is relatively low down, removal of the overlying palatal mucosa and bone will probably be all that is required to expose an adequate amount of clinical crown on to which a band or cast silver cap may then be placed. If this is not so, a canine may be left to erupt for a few months prior to placing some form of attachment. However, if the canine is placed high up in close proximity to the roots of the incisor teeth, adequate surgical uncovering with removal of bone to expose the widest diameter of the crown may endanger the incisors. This also often results in a tunnel at the top of which the canine crown may be just visible. As reorganization and epithelization usually proceeds at a faster rate than the eruption of the canine, the resulting scar tissue prevents any further eruption until the canine is again uncovered. This type of case requires some form of attachment to be applied to the crown of the canine so that tension can then be exerted to move the canine away from the adjacent teeth before moving it occlusally. Pins may be inserted into the crown but another method is the placing of a wire round the neck of the tooth. This method involves the raising of an adequate flap, followed by the removal of enough bone to gain access to the crown of the unerupted canine. Removal of the follicle by curettage provides adequate space into which a length of 0·3-mm. ligature wire may be fed around the crown of the tooth in the follicular space, using finger pressure to guide the wire rather than pliers. This is a similar manœuvre to the feeding of brass separating wires under the contact point prior to band construction. The lassoo wire is then positioned with a placer around the neck of the canine and tightened with Howes pliers or Spencer Wells forceps. The resulting tag may have a loop incorporated by inserting the point of a probe

Fig. 3.—A, Postero-anterior and lateral skull views showing unerupted 3|3. 3| is in a favourable position whereas |3 is in an unfavourable position. B, Palatal views following surgery to uncover 3|3 confirming radiographic assessment. (The photograph was taken in mirror and left and right are therefore reversed.)

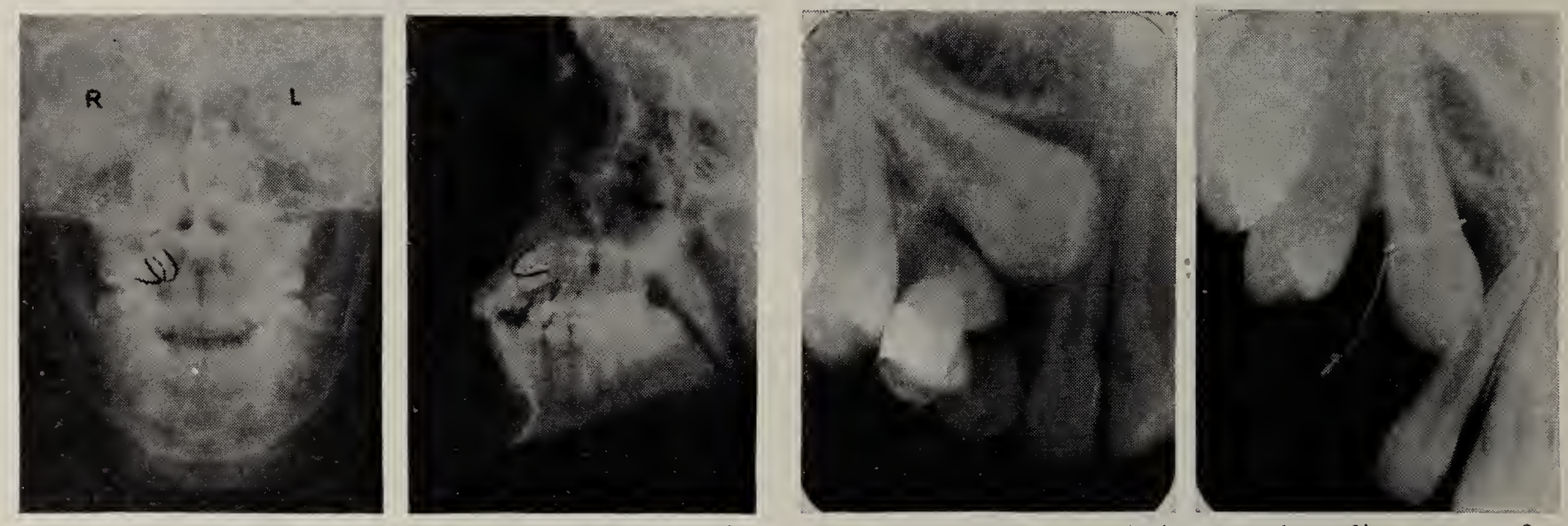


Fig. 4.—Skull films to locate the unerupted 3| which was above and palatal to horizontally displaced 4|.

Fig. 5.—Intra-oral views to show 3| at start of treatment and following removal of 4dc| the placing of lassoo round 3|.

around which one of the turns is made. The flap is then replaced with the wire tag lying in the incision line. It will be noted that, using this technique, only enough bone is removed to provide adequate access for the lassoo wire to be placed. Tension subsequently exerted on the wire will then move the unerupted tooth through the bone. The removal of bone to provide channels for eruption is to the condemned, and especially the removal of labial plate, as this bone takes a long time to be replaced and there often appears to be a permanent inadequacy of bone into which the tooth can be moved.

The use of the lassoo is illustrated by the following case report.

Case Report

Fig. 4 shows the postero-anterior and lateral skull views of a 13-year-old boy who presented with retained upper right deciduous canine and first deciduous molar. The upper right first premolar was lying horizontally below the right maxillary canine and clinically the buccal cusp of the first premolar was visible through the mucoperiosteum. The permanent canine was above and palatal to the first premolar at an angle of about 45° to the vertical.

The intra-oral views (*Fig.* 5) show the position of the canine before treatment and, following the removal of the deciduous teeth and first premolar, a lassoo wire was placed round the neck of the canine. Tension was exerted on the lassoo wire in a distal and occlusal direction from a light wire auxiliary which was activated by ligating it forward into the loop of the lassoo (*Fig.* 6). The buccal auxiliary was attached to the band on the first permanent molar which was stabilized by a palatal arch which can be seen on the lateral skull view.

Fig. 7A shows the position of the canine 6 months later when an adequate amount of clinical crown was available on to which a band was placed and the lassoo wire was removed. A modified pin-and-tube type of appliance was placed to move the apex of the canine mesially and the crown occlusally. These tooth movements were completed with a sectional arch (*Fig.* 7B) which had a 'stop' placed mesial to the tube on the molar to prevent the crown moving distally as the apex moved mesially. The repositioning of the right canine took 18 months to complete and *Fig.* 8 shows the position at the end of treatment.

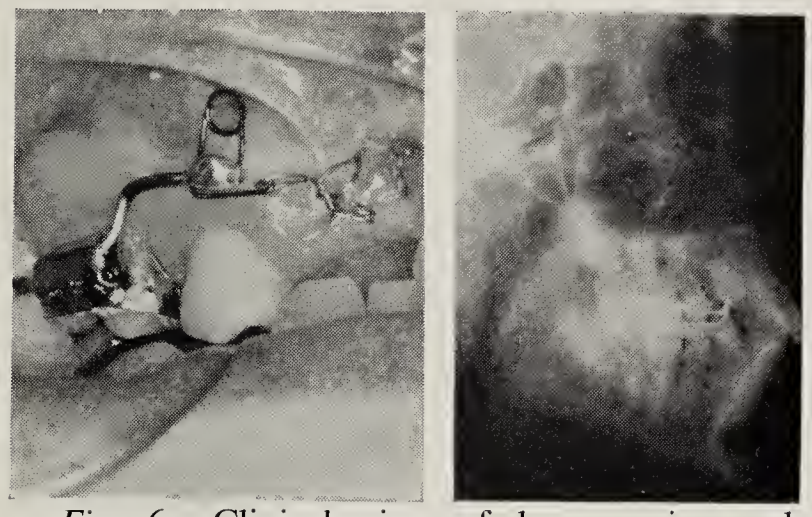
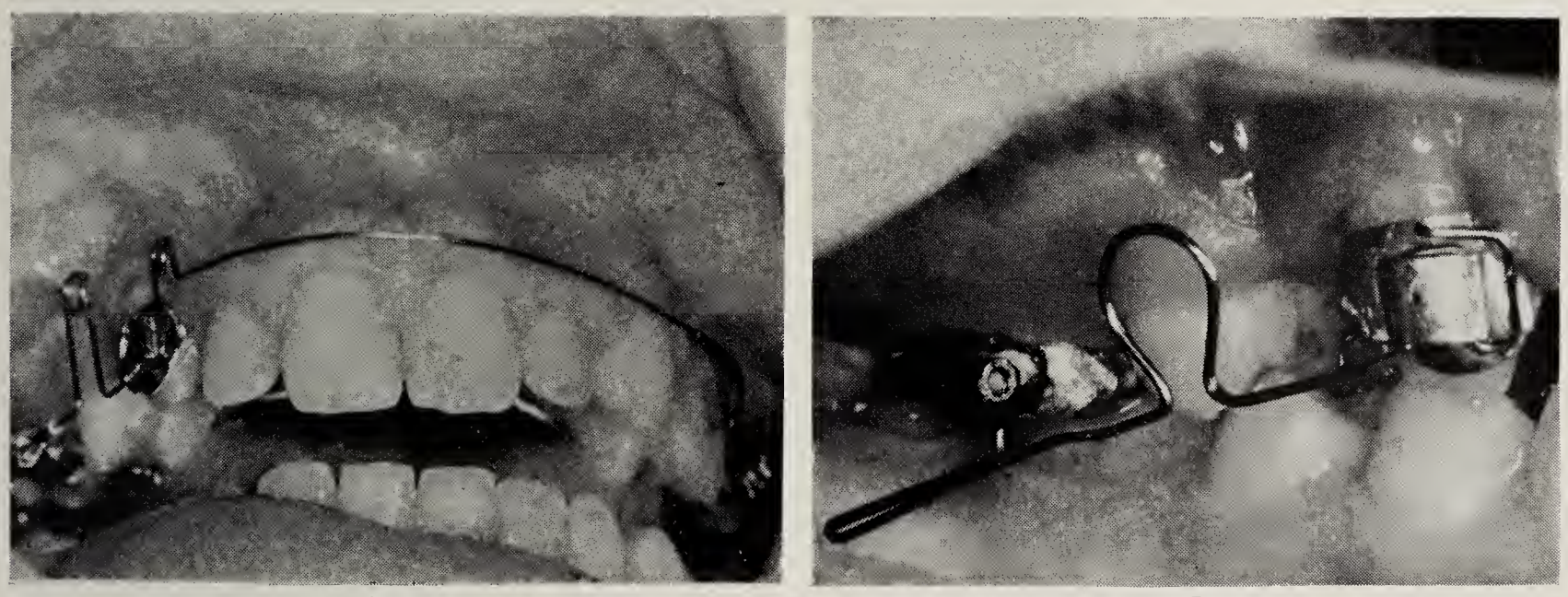


Fig. 6.—Clinical view of lassoo wire and auxiliary. Lateral skull view showing lassoo and distal movement of $\underline{3}|$ away from roots of incisors (compare with lateral skull in *Fig.* 4).



A B

Fig. 7.—A, Modified pin and tube appliance supported in end tube. B, Sectional pin and tube to move the apex mesially and the crown occlusally. Note the stop mesial to the $\underline{6}|$ tube.

Fig. 8.—Clinical appearance at the time the appliances were removed.

Consideration of the radiographic and surgical aspects of the unerupted canine has inevitably covered the methods of subsequent repositioning.

ORTHODONTIC REPOSITIONING

This involves the placing of a cast silver cap or band to which tension may then be exerted from a fixed or removable appliance. The following case report illustrates the repositioning of the lower canine in a 20-year-old woman.

Fig. 9.—Models to show the occlusion with a retained $\overline{|c}$.

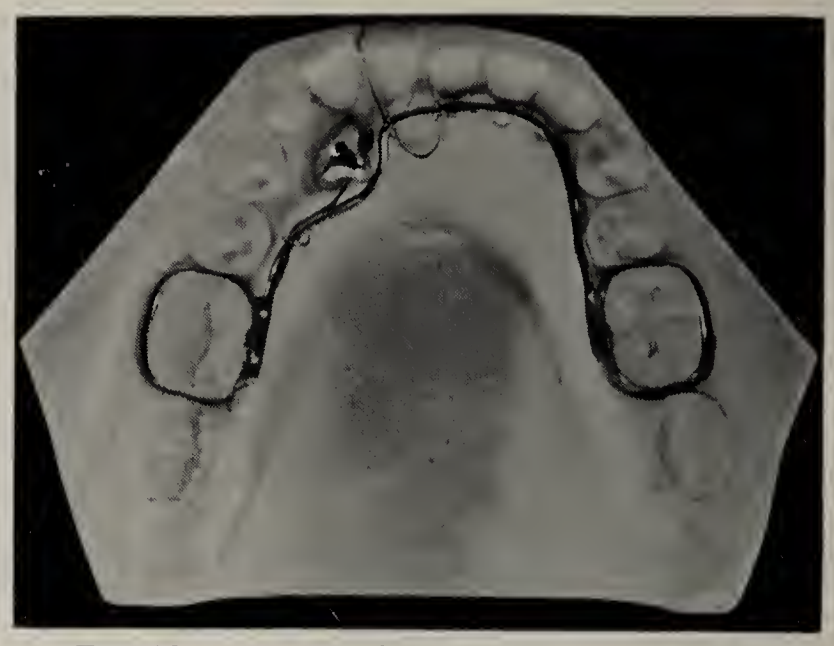
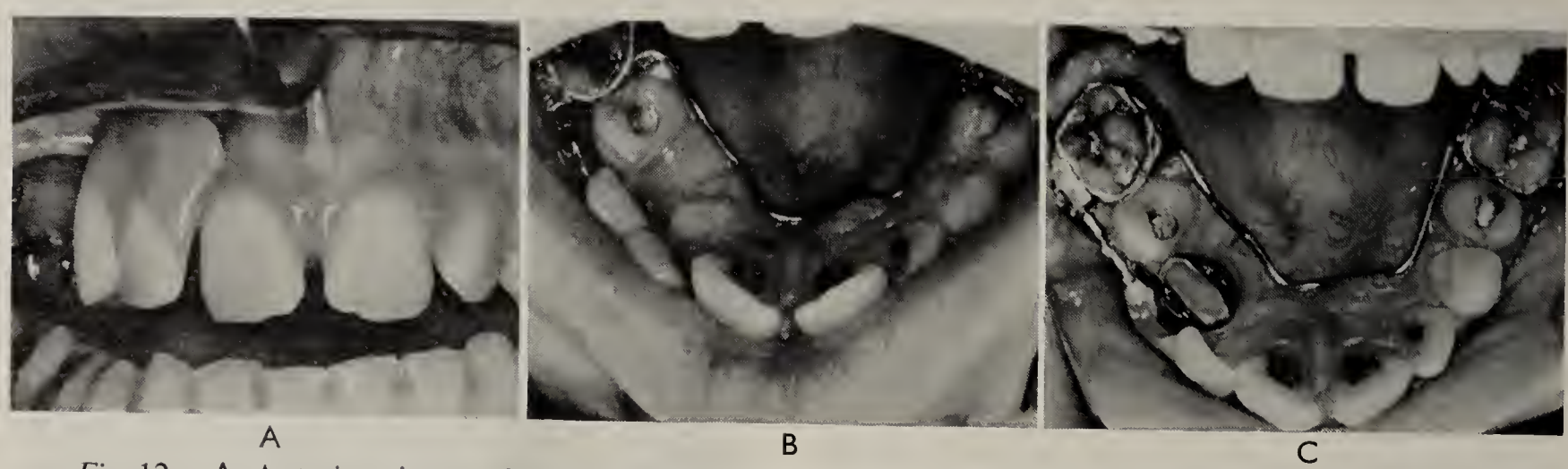


Fig. 10.—Model of the lower arch with the appliance in place. Note that the auxiliary to move $\overline{|3}$ buccally also had an occlusal component by inserting the spring under a lingual hook on the cast silver cap.

A B

Fig. 11.—A, Buccal occlusion following the repositioning of $\overline{|3}$. B, Occlusal mirror view of lower arch—the repositioned $\overline{|3}$ is therefore on the right of the illustration.



A B C

Fig. 12.—A, Anterior view to show prosthetic replacement for $\underline{32|}$. Note its insertion into double buccal tubes on $\underline{6|}$ band. B, Palatal mirror view to show the rotated $\underline{3|}$ erupting, unimpeded, between the prosthesis and the palatal arch. C, Palatal mirror view with $\underline{3|}$ banded and being rotated mesiolabially into the line of the arch with a sectional. Note the direct view of upper incisors at the top of the illustration.

Case Report

From the study models it was evident that she had a very acceptable occlusion except for the lower left deciduous canine which was retained with the permanent successor erupting lingually (*Fig.* 9).

A lingual arch was fitted (*Fig.* 10) to which a Rix type of auxiliary spring was attached to close the incisor spacing by moving them to the right, in conjunction with some interdental stripping. A further auxiliary engaged the lingual hook on the silver cap by which a buccal and occlusal force was applied to the permanent canine. As the permanent canine moved buccally so the deciduous canine was lost and the permanent successor finally alined with a band and buccal auxiliary.

Fig. 11 shows the occlusal and buccal views of the lower left canine several months after the completion of treatment.

Once a canine has been surgically uncovered, it can often be left to erupt especially if this is close to the normal eruption time, as illustrated by the following case report.

Case Report

Fig. 12A, B shows a girl who had four first premolars extracted to relieve crowding at 13 years. Subsequently the unerupted right maxillary canine was found to be palatally placed with an associated follicular cyst. The cyst had caused gross resorption of the lateral incisor root which proved to be unsaveable.

Following surgical uncovering or marsupialization of the permanent canine it was left to erupt for a year. However, as the patient was receiving intensive treatment for acute episodes of depression, it was felt that her appearance should be made as acceptable as possible. To allow the upper right canine to erupt a palatal arch soldered to molar bands was fitted, rather than an acrylic type of appliance, and into buccal tubes on the right molar band a sectional type of prosthesis was slotted. She was instructed to wear the prosthesis only during the day.

When the canine had erupted sufficiently to place a band (*Fig.* 12C) a sectional arch was used to rotate and retract the canine under the acrylic façade from which the acrylic canine had eventually to be removed. It will be noted that the canine has been rotated and retracted into the line of the arch and was finally being moved buccally.

SUMMARY

1. The use of the postero-anterior and lateral skull radiographs in conjunction with an intra-oral view is discussed as a method of localization and assessment of the unerupted canine.

2. The surgical aspect is considered when the canine is in such a position that simple uncovering will enable the placing of a band or cast silver cap. Also the indication for the use of a lassoo wire is described when the canine is high up and in close proximity to the incisor roots.

3. Methods of orthodontic repositioning have been shown which essentially involve the placing of bands or caps to which various attachments from fixed or removable appliances can be applied.

Acknowledgements

I am indebted to Professor C. F. Ballard, Dr. J. R. E. Mills, and Mr. S. G. McCallin for their advice and permission to publish their cases. Also to Professor G. B. Winter and Mr. D. Downton for letting me participate in the surgical procedures. My thanks are also due to the Photographic Department of the Eastman Dental Hospital and to Mr. Close for his assistance in the preparation of the models. Finally, I should also like to express my gratitude to the secretarial staff of the Orthodontic Department for their clerical assistance.

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DISCUSSION

Dr. J. R. E. Mills said that he had no personal experience of using a lassoo method, and he wished to ask about two technical points. Firstly, presumably Mrs. Wraith placed the lassoo at operation and inserted the rest of the appliance at a later visit. In that case, was there any difficulty with the protruding end of the wire? Did she have to do anything special to prevent it annoying the patient? Also, since at the end of treatment the lassoo had to be removed, was there any difficulty involved in this?

Mrs. Wraith said that to begin with, the end of the wire was covered by a pack and when that was removed she started orthodontic treatment. That overcame the question of the wire worrying the patient.

With regard to its removal, provided one remembered always to wind the wire in a clockwise direction, it was easy to remember to unwind it in an anti-clockwise direction, and by cutting one side, it was possible to pull it through in the same way as with a circumferential wire.

Mr. J. H. Gardiner congratulated Mrs. Wraith upon showing a list of the doses of the different X-ray views. He asked how the radiographic dosage was measured.

Mrs. Wraith replied that these were figures given to her by Dr. Prior and Dr. Ingram. The extra-oral views could be assessed with a dosemeter and the other views were from work done at Guy's Hospital which she believed was due to be published.

Mr. H. Lester asked whether it was possible to take an accurate lateral skull extra-oral film without the use of a cephalostat?

Mrs. Wraith replied that although she had never tried to do so, she thought that provided the rays were at right angles and there was no distortion or rotation, this would be feasible. Two X-rays at right angles to each other are required and the standardized method of using a cephalostat made this easy.

Mr. D. Seel said that oral surgeons did sometimes have difficulty in locating an unerupted canine and even found on occasions that their attempt to expose the tooth had been made from the wrong side. The difficult ones are those close to the line of the arch. On a true lateral radiograph of such a situation it can be difficult to follow the outline of the tooth, and on an occlusal view a high canine can appear to be palatal when it is in fact buccal unless a view taken down the long axis of all the teeth concerned can be obtained. Has Mrs. Wraith any special tips as to how to deal with this situation?

Mrs. Wraith pointed out that she had said that it was not an infallible method. She was sure that this must happen to everyone, but the method she had described gave the greatest amount of information from which it was possible to assess the canine and localize it accurately.

Dr. J. D. Atherton said that he had found that the vertex occlusal radiograph was useful. It gave a very precise view of the teeth in the arch. It was possible to see distinctly where the canine was—labially, buccally, or in the line of the arch. In conjunction with the lateral radiograph it really provided an excellent service.

Mr. H. Lester referred to the vertex occlusal radiograph and said that he used occlusal radiographs in a cassette with high-speed screens, and this cut down the dosage to within normal limits. Only one film was being taken, and provided the patient was not one whose dosage had been exceeded within the permitted time, he could see no objection to the use of the vertex occlusal.

Mrs. Wraith replying to Dr. Atherton, said that the main objections to the vertex occlusal were, firstly, that the relationship of the canine to the lateral incisor was an important one. In a vertex occlusal where the rest of the root canals were pin-pointed, because the lateral incisor developed more palatally, often the pulp canal was not a pin-point due to its angulation, or a distorted view of the root of the lateral might be obtained and there would therefore be difficulty in relating the canine to this.

Secondly, the beam was being directed towards the gonads and a higher dosage was carried with the vertex occlusal than the radiographs she had described and this was another contra-indication for using it. But she was sure that to someone who was accustomed to using their particular method, it was almost as satisfactory as localizing the canine with the use of the postero-anterior, lateral skull, and intra-oral films.

Mr. R. T. Broadway pointed out that no one had mentioned the tube shift method, which he thought, had rather an important part to play in determining whether a canine was palatal or buccal. If in the difficult cases, it was almost in the line of the arch, he made a plea to the oral surgeon to approach it from the palatal side always and not from the buccal side.

Mrs. Wraith agreed and said that the only trouble was that although this would give the buccopalatal relationship, it did not give any idea of the height.

Mr. Broadway said that he meant this in conjunction with a lateral skull and postero-anterior skull. If one was still not quite sure in spite of having those, a couple of intra-orals with a tube shift could be quite helpful.

Mrs. Wraith agreed.

PREVALENCE OF MALOCCLUSION IN FIFTEEN-YEAR-OLD CHILDREN FROM FLUORIDE AND NON-FLUORIDE COMMUNITIES

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THE purpose of this study was to compare the prevalence of malocclusion and need for orthodontic treatment in 15-year-old children from fluoride and non-fluoride communities. The communities studied were West Hartlepool, where for generations past the level of fluoride naturally present in the drinking water has been 1·5–2·0 parts per million (p.p.m.), and York, where the level of fluoride in the drinking water varies from 0·15 to 0·28 p.p.m. F with a mean of 0·2 p.p.m. F. The two towns are of similar size and socio-economic structure (Registrar-General, 1963). Caries experience in York children is similar to the ' national average ' for this country (Murray, 1968). For these reasons the York community was chosen as a control town.

MATERIAL AND METHODS

In January, 1967, letters were sent to the parents of every 15-year-old child attending West Hartlepool schools asking them to state whether their child had:—

1. Been born and bred in West Hartlepool.
2. Lived all its life in the town.

Only if the answer to both these questions was ' yes ' was the name of the child placed on the examination list. A total of 385 15-year-old children from 9 West Hartlepool secondary schools was examined over the period from March to September, 1967.

During January, 1968, 381 15-year-old York children from 9 secondary schools were examined.

All dental examinations were carried out at the respective schools by the same examiner. Each child when examined sat on a portable chair fitted with an adjustable headrest; an ' Anglepoise ' lamp was used to provide a consistent source of light. The age of the child was taken as at the date of examination, correct to the completed month.

STANDARD OF DIAGNOSIS

1. Anteroposterior Arch Relationship

A normal anteroposterior arch relationship was defined as ' one in which the mandibular canine normally occluded in the embrasure between the maxillary canine and maxillary lateral '. If the mandibular canine occluded distally to the embrasure between the maxillary canine and maxillary lateral, this was termed ' a postnormal arch relationship '. If the mandibular canine occluded mesially to the embrasure between the maxillary canine and maxillary lateral, this was termed ' a prenormal arch relationship '.

If the canine teeth were not present or grossly displaced, then the occlusion of the buccal segments was observed.

An arch was considered to be crowded if the mesiodistal width of a tooth could not be accommodated within the smooth curve of the arch. The site of crowding in incisor, canine, or premolar region, in each arch, was recorded.

If there was no crowding or rotation at any site in either arch of a child with a normal arch relationship, this was termed ' a *normal* occlusion '.

If crowding or rotations did occur in a child with a normal anteroposterior arch relationship, this was termed a Class I malocclusion.

A child with a postnormal arch relationship was said to have a Class II malocclusion.

A child with a prenormal arch relationship was said to have a Class III malocclusion.

2. Need for Orthodontic Treatment

Each malocclusion was assessed for severity and graded into two groups:

a. No Orthodontic Treatment Needed

This category comprised mild malocclusions with slightly rotated or crowded teeth considered to be of no aesthetic or functional significance.

Presented at the Research Meeting held in Leeds on 10 April, 1969.

b. Orthodontic Treatment Needed or Given

In this category were placed those with more severe malocclusions where it was considered that orthodontic treatment (extractions and/or appliance therapy) would substantially improve the occlusion.

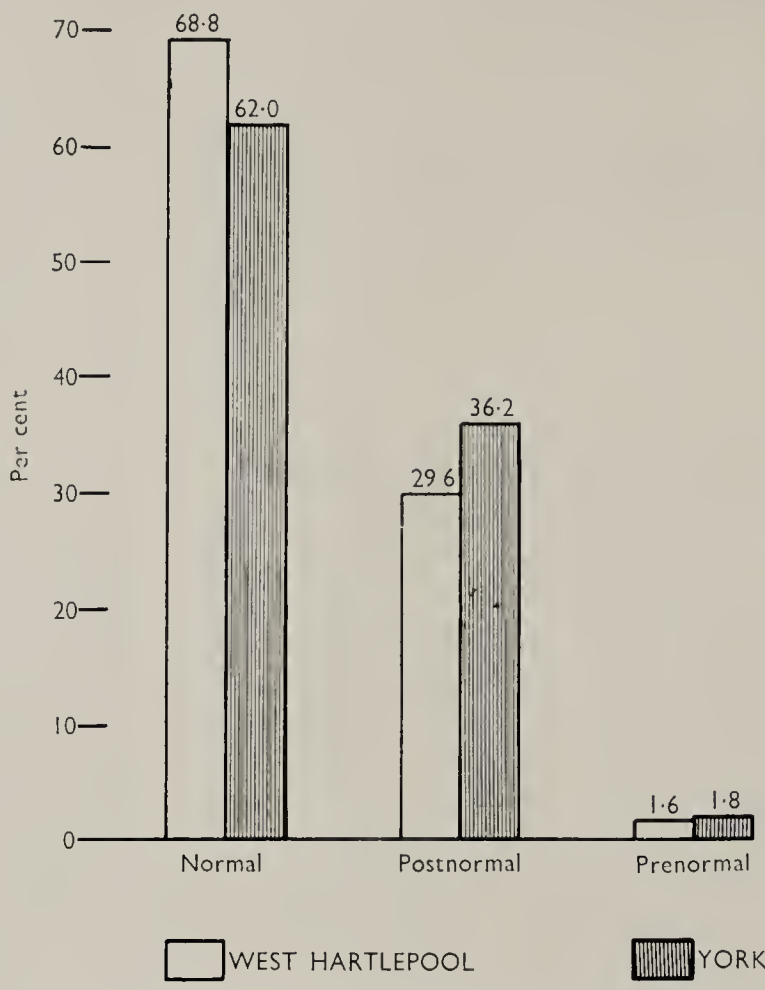

Fig. 1.—Prevalence of normal, postnormal, and prenormal arch relationships in 15-year-old children.

respectively; the analogous figures for York were 62·0, 36·2, and 1·8 per cent respectively. These results are presented diagrammatically in *Fig.* 1. The difference between the two sets of figures is not statistically significant ($P>0{\cdot}05$, $\chi^2=4{\cdot}02$, $n=2$).

2. Prevalence of Normal Occlusion and Class I, II, and III Malocclusions

The number of children with a *normal* occlusion and with each type of malocclusion is recorded

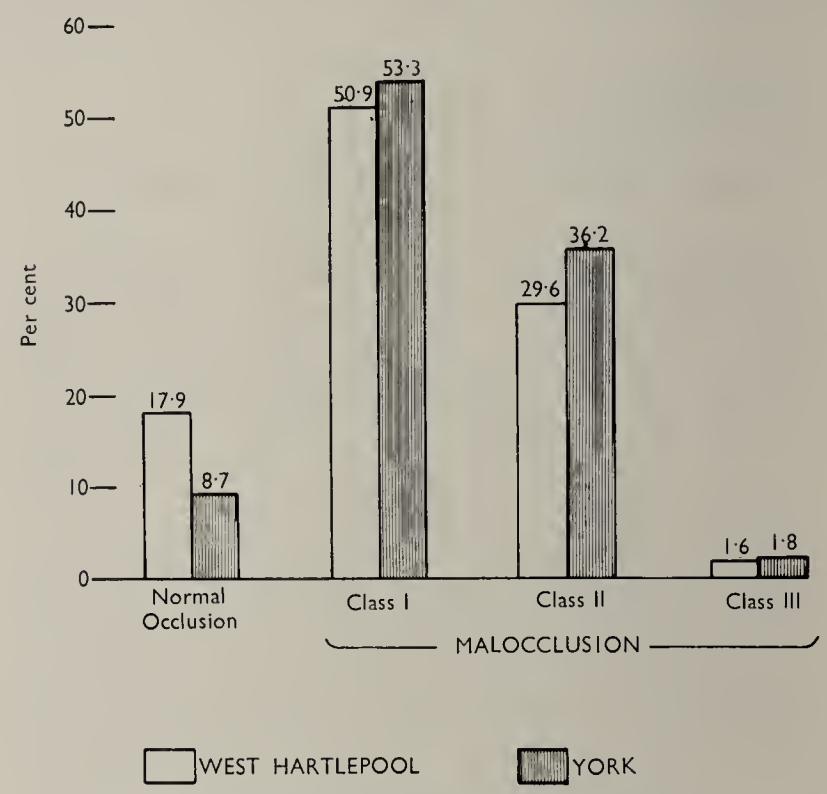

Fig. 2.—Prevalence of *normal* occlusion and Class I, II, and III malocclusion in 15-year-old children.

Table I.—The Distribution of Anteroposterior Relationships

Area	No. of Children	Normal Occlusion		Malocclusion					
				Class I		*Class II*		*Class III*	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
West Hartlepool	385	69	17·9	196	50·9	114	29·6	6	1·6
York	381	33	8·7	203	53·3	138	36·2	7	1·8

Any child who had received treatment to improve the occlusion, either involving extractions only or involving appliance therapy, was said to have received orthodontic treatment.

RESULTS

1. Prevalence of Normal, Postnormal, and Prenormal Anteroposterior Arch Relationships

In West Hartlepool the percentage of normal, postnormal, and prenormal anteroposterior arch relationships was 68·8, 29·6, and 1·6 per cent

in *Table I* and presented diagrammatically in *Fig.* 2.

Twice as many West Hartlepool children had a *normal* occlusion (17·9 per cent) compared with York children (8·7 per cent). This difference is statistically significant at the 0·1 per cent level of probability ($\chi^2=14{\cdot}23$, $n=1$).

The prevalence of each type of malocclusion was found to be similar in each community. In West Hartlepool the prevalence of Class I, II, and III malocclusions was 50·9, 29·6, and 1·6 per cent respectively; the analogous figures for York

were 53·3, 36·2, and 1·8 per cent respectively. The difference between these two sets of figures is not statistically significant ($P>0·05$, $\chi^2=0·057$, $n=2$).

3. Need for Orthodontic Treatment

The need for orthodontic treatment in the two communities is recorded in *Table II*. Treatment was either needed or had been given in 31·9 per cent of children in West Hartlepool and 39·6 per cent of children in York. This difference is statistically significant at the 5 per cent level of probability ($\chi^2=4·92$, $n=1$).

4. Mouth Prevalence of Crowding

Mouth prevalence of crowding was found to be very high in both communities. The number of West Hartlepool and York children found to have crowding in at least one site in the mouth is given in *Table III*. Mouth prevalence of crowding was 74·3 per cent in West Hartlepool children and 80·6 per cent in York children. The difference between these figures is statistically significant at the 5 per cent level of probability ($\chi^2=4·34$, $n=1$).

5. Prevalence of Crowding in Incisor, Canine, and Premolar Regions

In order to determine whether the slightly higher prevalence of crowding in York was confined to any particular site, the prevalence of crowding in incisor, canine, and premolar regions was recorded. However, the measurement of crowding in individual sites is complicated by the intervention of dental treatment. When teeth have been extracted as an integral part of orthodontic treatment it is not possible to say whether crowding had existed at the site of extraction. Therefore, any child who had received orthodontic treatment was excluded from this part of the investigation. (This procedure affected both communities almost equally: 18·7 per cent of West Hartlepool children and 21·5 per cent of York children were considered to have received orthodontic treatment.) The prevalence of crowding at incisor, canine, and premolar regions, excluding those who had received orthodontic treatment, is recorded in *Table IV* and presented diagrammatically in *Fig*. 3. These figures are from 313 West Hartlepool children and 299 York children. No significant difference between the two communities was observed in the prevalence of crowding in incisor, canine, or mandibular premolar regions. In both communities maxillary and mandibular incisor crowding occurred in over 40 per cent of cases. Crowding in the canine region occurred in approximately 11 per cent of children in the maxilla but in 8 per cent of children in the mandible. In only one site, the maxillary premolar region, was crowding statistically significantly higher in York than in West Hartlepool ($P<0·01$, $\chi^2=8·91$, $n=1$). However, premolar crowding can be relieved by the extraction of first permanent molars. It is possible that intrinsic premolar crowding has been masked by an imbalance in the number of first permanent molars extracted in the two communities. The number of children who had lost at least 1 maxillary first molar and the number who had lost at least 1 mandibular first molar, in each community is recorded in *Table V*. Overall, the mortality of first permanent molars is higher in York than in West Hartlepool. However, in West Hartlepool the number of children who had lost maxillary first molars was

Table II.—Need for Orthodontic Treatment

Area	No. of Children	Orthodontic Treatment Needed		Orthodontic Treatment Given	
		No.	Per cent	No.	Per cent
West Hartlepool	385	51	13·2	72	18·7
York	381	69	18·1	82	21·5

Table III.—Mouth Prevalence of Crowding

Area	No. of Children	No. of Children With Crowding in at least one Site	Mouth Prevalence of Crowding
West Hartlepool	385	286	74·3
York	381	307	80·6

similar to the number who had lost mandibular first molars, but in York 67 per cent more children had lost mandibular first molars than maxillary first molars. It is, therefore, possible that mandibular premolar crowding has been relieved to a greater extent in York than in West Hartlepool

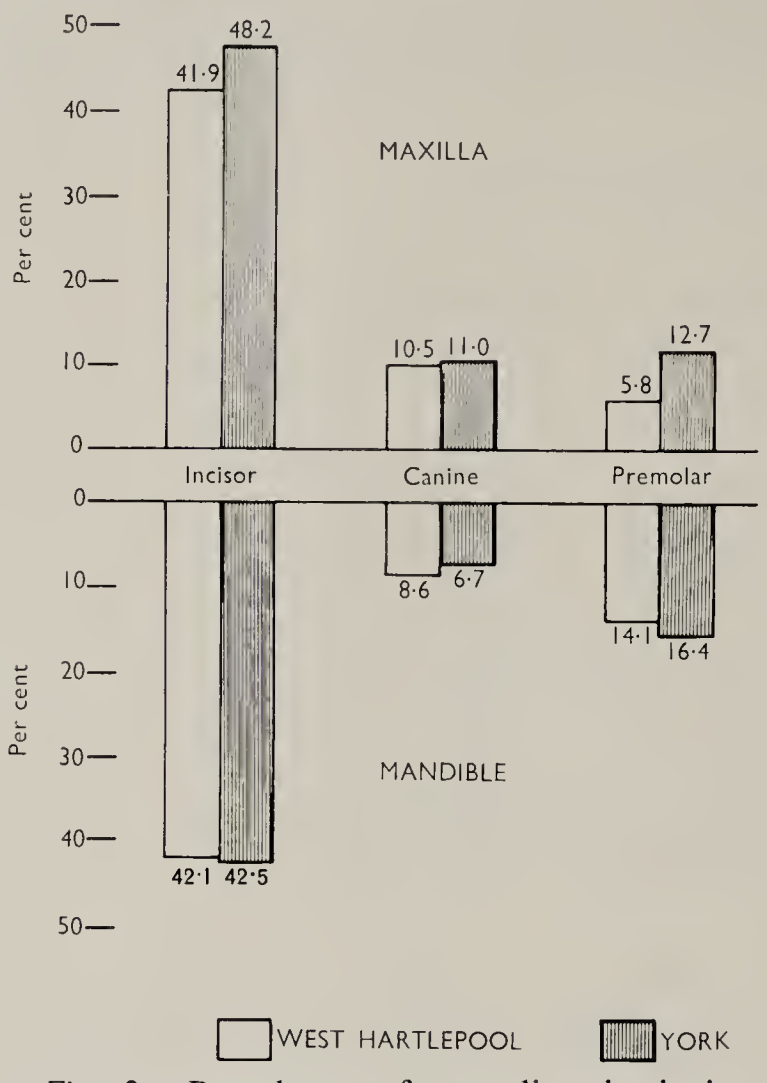

Fig. 3.—Prevalence of crowding in incisor, canine, and premolar regions in 15-year-old children.

that fluoride drinking waters have any direct effect on the distribution of anteroposterior relationships. It is possible that the caries-inhibitory property of fluoride drinking water could have an indirect effect on the prevalence of malocclusions, by reducing the number of teeth which have to be extracted because of advanced caries, and thereby reducing the number of seriously disturbed occlusions. In this study it was observed that the prevalence of *normal* occlusion was twice as high in 15-year-old West Hartlepool children (17·9 per cent) as in

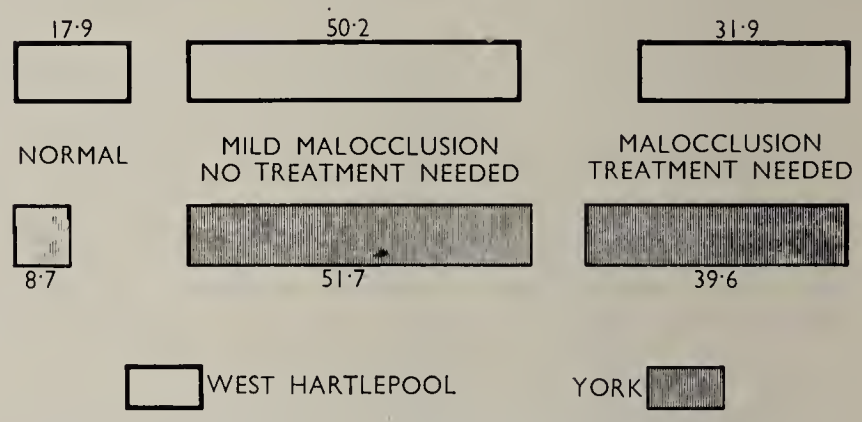

Fig. 4.—Need for orthodontic treatment in 15-year-old children.

York children of the same age (8·7 per cent). The percentage of children in need of (or receiving) orthodontic treatment was slightly lower in West Hartlepool than in York (31·9 per cent as against 39·6 per cent). The remaining children, approximately 50 per cent in both communities, although not possessing *normal* occlusions, had acceptable occlusions for which orthodontic treatment was not deemed necessary. These results are summarized in *Fig.* 4.

Table IV.—The Site of Crowding in Cases who had not received Orthodontic Treatment

Area	No. of Children	Site of Crowding					
		Maxilla			*Mandible*		
		Incisor	Canine	Premolar	Incisor	Canine	Premolar
West Hartlepool	313	131	33	18	133	27	44
York	299	144	33	38	126	20	49

by the greater extraction rate of mandibular first molars in York.

DISCUSSION

No significant difference was observed in the distribution of normal, postnormal, and prenormal anteroposterior arch relationships in 15-year-old children from West Hartlepool and York. Therefore, there is no evidence to suggest

It is possible that the higher caries rate in York is responsible for removing 9 per cent of children from the ' normal ' category and placing them in the ' mild malocclusion ' group and complicating 8 per cent of children in the ' mild malocclusion ' group and placing them in the orthodontic treatment needed category.

Mouth prevalence of crowding was very high in both communities, and was slightly higher in York than in West Hartlepool (80 per cent as

against 74·3 per cent). Excluding those who had received orthodontic treatment, crowding occurred most frequently in the incisor region in both communities, both in the maxilla and in the mandible. In only one site, the maxillary premolar region, was the prevalence of crowding significantly higher in York than in West Hartlepool. However, premolar crowding can be relieved by extraction of first permanent molars. In York, 67 per cent more mandibular first molars were extracted than maxillary first molars, and this imbalance in the extraction rate between maxilla and mandible could have masked the true pattern of premolar crowding in York.

The slightly higher mouth prevalence of crowding, and the significantly higher prevalence of maxillary premolar crowding in York could be due to the fact that a greater proportion of deciduous molars are lost prematurely in York, the low fluoride area, so allowing a greater proportion of first permanent molars to drift forward, resulting in loss of space in the premolar region.

Table V.—Pattern of First Permanent Molar Extraction Rate in Cases who had not received Orthodontic Treatment

Area	No. of Children	At Least 1 Maxillary First Molar Extracted		At Least 1 Mandibular First Molar Extracted	
		No.	Per cent	No.	Per cent
West Hartlepool	313	45	14·4	51	16·3
York	299	61	20·4	102	34·1

Previous Studies

There have been few previous studies of the prevalence of malocclusion in fluoride and non-fluoride areas. Hill, Blayney, and Wolf (1959) examined the occlusion of 12–14-year-old children taking part in the Evanston Dental Caries Study. They concluded that ' no definite statement could be made regarding fluoridation and its effect on the prevalence of malocclusion '. Walther (1960) determined the skeletal and arch anteroposterior relationships of 1000 East Anglian schoolchildren aged 11–13 years, living in high and low fluoride areas in East Anglia. The highest percentage of Skeletal I and Angle Class I cases occurred in those children who had lived continuously in the high fluoride area of Colchester.

Ast, Allaway, and Draker (1962) examined 302 sets of study models of 13–14-year-old children from the fluoride town of Newburgh and the control town of Kingston. The proportion of Newburgh children with a normal occlusion was 35·2 per cent, approximately 2·8 times that found in children from the non-fluoride town of Kingston (12·7 per cent).

It is difficult to make valid comparisons between previous studies and the present study, firstly because the criteria for classifying *normal* occlusion are not uniform, and secondly, because the clinical determination of malocclusion is highly subjective. In this study the definition of *normal* occlusion employed was very strict, in that any mouth with a tooth or teeth slightly crowded or rotated in either arch was excluded from the *normal* category. Ast and others (1962) adopted a less strict definition of *normal* occlusion—normal molar relationship with no orthodontic treatment indicated or desirable—and this is probably the reason why the prevalence of *normal* occlusion in their study was much higher than in the present study.

CONCLUSION

It is concluded, from the information presented in this study, that there is no evidence to suggest that fluoride drinking-waters have any direct effect on anteroposterior arch relationships, nor do they substantially reduce the prevalence of malocclusions, or substantially reduce the need for orthodontic treatment. But the caries-inhibitory property of fluoride drinking-water reduces the number of teeth, particularly deciduous molars and first permanent molars, which are lost prematurely because of advanced caries. This simplifies orthodontic treatment in some cases because of the much smaller need to incorporate in orthodontic treatment plans the extraction of severely carious teeth, particularly first permanent molars.

SUMMARY

1. No significant difference was observed in the distribution of normal, postnormal, and prenormal anteroposterior arch relationship in 15-year-old children from West Hartlepool and York.

2. Twice as many children had a *normal* occlusion in West Hartlepool compared with York (17·9 per cent as against 8·7 per cent).

3. The percentage of children in need of (or receiving) orthodontic treatment was slightly

higher in York compared with West Hartlepool (39·6 per cent as against 31·9 per cent).

4. Mouth prevalence of crowding was slightly higher in York children than in West Hartlepool children (80 per cent as against 74·3 per cent).

5. Excluding those who had received orthodontic treatment maxillary premolar crowding was significantly higher in York children than in West Hartlepool children.

Acknowledgements

This study was facilitated by a research grant from the Joseph Rowntree Memorial Trust. I am indebted to Professor D. Jackson for his encouragement and supervision. I also wish to express my appreciation to Dr. H. Milligan, Medical Officer of Health, Hartlepool, Mrs. K. Atkinson, Chief Dental Officer, Hartlepool; Mr. G. Turner, Chief Dental Officer, York, and all head teachers in the schools visited for their kind help and co-operation.

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A CEPHALOMETRIC APPRAISAL OF CASES OF ANGLE'S CLASS II, DIVISION 1 MALOCCLUSION TREATED BY THE ANDRESEN APPLIANCE

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FUNCTIONAL jaw orthopaedics has been practised by orthodontists for well over 40 years. The functional appliance in most common use today is the Andresen appliance, variously referred to as the ' activator ', ' Norwegian plate ', or ' monobloc '. By harnessing muscle forces acting upon the mandible, the Andresen appliance provides a powerful yet safe means of intermaxillary traction in the treatment of Angle's Class II malocclusions. In spite of its many advantages, the appliance has been criticized as being clinically unpredictable and difficult for the patient to tolerate; it is also alleged to procline the lower incisors during treatment, leading to subsequent relapse and imbrication.

It is perhaps unfortunate that the Andresen has undergone more than its fair share of modifications in the hands of different operators, and the clinical techniques employed in its use appear to be many and various. Possibly this has contributed to the mystique and disrepute in which the appliance is held by a considerable proportion of orthodontists in this country.

The most provocative issue, however, has always been whether the Andresen appliance achieves its results merely by simple tooth movement within the jaw structures, or whether in addition it is capable of altering the bony environment. On the precept that the growth potential of an individual structure is genetically determined in extent, it would seem unlikely that the ' dental base ' relationship might be influenced by an orthodontic appliance, particularly the length of the mandible.

The concensus of opinion in this country, based almost entirely on ' clinical impression ', is that the skeletal pattern is unalterable during Andresen treatment. On the other hand, while few Andresen enthusiasts would seriously claim to be able to modify the skeletal pattern to choice, the majority of cephalometric studies support the view that the changes produced are not confined entirely to the teeth.

THE LITERATURE

Some idea of the differing opinions on this subject may be gained from the symposium on functional therapy held in Plymouth in 1964.

In the panel discussion, Dickson (1965) stated that he had not observed any change in skeletal pattern during Andresen therapy that could not have taken place with natural growth. Dr. Mills (1965) supported this view, adding that the changes produced were small, unpredictable, and open to other interpretation. Professor Moyers (1965) suggested that a favourable change in the dental base relationship may occur in a small proportion of cases, which is followed by a lag in growth, so that by maturity the individual shows no advantage.

Dr. Grossman (1965) put forward a different opinion, that in certain cases of Class II, division 1 malocclusion the mandible fails to realize its full growth potential on account of restraining factors in its environment. By releasing these factors, the Andresen appliance enables the mandible to attain its genetically determined length. It may also inhibit maxillary growth, as may other forms of traction.

Cephalometric investigations have to some extent conflicted as to the nature and degree of the changes attributable to the Andresen appliance.

Björk (1951) claims that only the teeth and alveolus undergo change during treatment. He observed no skeletal changes outside the range of normal growth in the 3 Class II cases that he analysed, although with so small a sample this is

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Presented at the meeting held on 10 March, 1969.

hardly valid as a growth study. Similarly, Softley (1953) investigated 7 Andresen cases finding no change in ∠SNB but a small decrease in ∠SNA in some instances.

The most convincing evidence against skeletal change may be found in Jakobsson's paper (1967). Fifty-seven patients with Class II, division 1 malocclusions were grouped into evenly matched triads. Treatment was decided by lot within each triad so that one patient received extra-oral traction, another an Andresen appliance, while the third remained untreated. Cephalometric analysis revealed that the maxilla was retroposed to a greater extent in the headgear group than the Andresen cases. There was no variation in mandibular position within the three groups, but the lower incisors moved forward bodily in the Andresen patients.

Stating the opposite view, Gresham (1952) found an increase in the angle S–N–pogonion of up to 3° in a year in 20 Andresen cases, compared with an equal number of untreated controls. He also claimed radiographic changes in the position of the condyle head. Similarly, Moss (1962) presented 30 successful Andresen cases, showing a positive change in maxillo-mandibular relationship in 76 per cent of cases, using linear measurements on cephalometric headplates based on 'A' and 'B' points.

More recently Marschner and Harris (1966) examined the length of the mandible radiographically from condyle to chin point. They demonstrated a significant increase in 12 Andresen patients of between 0·9 mm. and 1·5 mm. per annum compared with 23 untreated control cases. The authors suggested that the mandible had been encouraged to reach its inherent potential of growth in the Andresen patients, but that these changes would not be reproduced thereafter, even with continued treatment.

Meach (1966) compared 3 large groups of cephalometric radiographs. Thirty-four untreated Class I cases and 46 Class II, division 1 cases treated by extra-oral traction, both from Washington, were compared with 30 Andresen cases from Bonn. Unfortunately the different techniques in cephalometric radiography precluded direct linear comparison, but the angle S–N–pogonion increased in 87 per cent of Andresen treated cases compared with 45 per cent of cases in the headgear group. The former figure was almost identical to the Class I control group, the inference being that the Andresen appliance had normalized mandibular growth. Backward movement of point A was greater in the headgear group than the Andresen patients.

Perhaps the most dramatic skeletal changes are those claimed by Freunthaller (1967) who analysed cephalometric headplates from 35 Andresen cases which he described as 'excellent treatment results'. He attributed the clinical improvement to a combination of skeletal and dento-alveolar changes. In only 10 per cent of cases was no sagittal skeletal change demonstrable. He claimed that in no less than 40 per cent of cases the skeletal changes alone were sufficient to account for a full premolar unit of improvement in the buccal occlusion. Ten per cent showed a skeletal change of twice this magnitude, but it was conceded that such changes were unpredictable.

The most recent communication to date is that of Trayfoot and Richardson (1968) who compared 17 Andresen with 17 control cases (untreated). The result was statistically positive in favour of the Andresen patients for ∠SNA, but ∠SNB showed no significant increase compared with the untreated subjects.

To summarize briefly, Björk (1951) in his 3 cases demonstrated no skeletal changes in either jaw. Jakobsson (1967), Trayfoot and Richardson (1968), and, to a lesser extent Softley (1953), showed a small backward movement of point 'A' but no significant advance of point 'B'. Gresham (1952) and Marschner and Harris (1966) examined the mandible only, with positive findings. Moss (1962) and Meach (1966) found an improvement in both jaws, while Freunthaller (1967), in relating mandible to maxilla by Schwartz's method, measured only the total change without differentiating convincingly between the two components.

INTENTION

It is widely acknowledged that growth patterns vary between individuals within reasonable limits, both in timing and extent. Nature seldom conforms exactly to the 'normal' prescribed for her by the statistician in any one case. If, in a Class II, division 1 malocclusion, the mandible undergoes natural growth in excess of the normal, it is logical to assume that this will predispose towards a more satisfactory clinical outcome. Is it not possible, therefore, that by selecting the most successful Andresen results, we are grouping together those cases with a favourable growth pattern which may have been coincidental to the wearing of the appliance? If the exception proves the rule, a group of exceptions must be even more convincing!

It is notable that among the investigators purporting to show a change in skeletal pattern, none has declared the criteria for selection of the Andresen treatments under study. Particularly as the majority are retrospective studies, it is not unreasonable to assume that the 'best results' have been chosen.

It was for this reason that I decided to embark upon an investigation of Andresen treated cases selected without regard to the clinical result. It

was anticipated that this would mitigate against a positive result in terms of the landmarks under study.

MATERIAL

The criteria adopted for case selection were as follows:—

1. A positive difference between ∠SNA and ∠SNB of at least 4°.
2. An incisor overjet of at least 5 mm.
3. No extractions of permanent teeth in the lower arch before or during treatment.
4. A complete set of records.

The first two criteria define a Class II, division 1 malocclusion in terms of skeletal and incisor relationship for the purpose of this paper.

The third criterion excludes the grossly crowded lower arch, also the possible effect on the lower labial segment of uncontrolled extractions. It should be mentioned, however, that the extraction of second permanent molars was ignored, as it was considered that the effect on the lower incisors would be minimal.

The records of 1200 cases treated consecutively at University College Hospital were examined. All cases satisfying the above criteria were included in the series irrespective of the clinical success or otherwise of the treatment although, naturally, cases which failed to complete the treatment under study were excluded on the grounds of incomplete records.

The 76 cases thus obtained were then separated into Andresen and control groups. The Andresen group consisted of the 46 cases in which an Andresen appliance had been used for intermaxillary traction. In some instances this constituted the main phase of the treatment, while in others the appliance was only in use for a small proportion of the total time as a stage in the treatment. None of the Andresen patients received upper arch extractions (except the upper second permanent molars in some instances).

The remaining 30 cases comprised the control group, the majority of which were treated by the extraction of upper premolars. Others underwent distal movement of the upper buccal segments (by means of Schwartz-type appliances) or, in some cases, simple retraction of the upper labial segment. Extra-oral traction was not used.

In general, no treatment was carried out within the lower arch in either group. There were exceptions, however (4 Andresen and 8 control cases), in which a small amount of antero-posterior expansion had been attempted to relieve minimal incisal crowding. (In the later analysis the effect on the lower incisal tip was found to be negative. These cases were therefore included in the calculations.)

As far as can be ascertained, the original choice of treatment plan was based on the personal preference of the operators, one for the Andresen method, the other for upper arch extractions. No obvious morphological differences were noted between the two groups which might have influenced the decision as to which treatment to employ. It would, of course, be quite unjustified to infer from this that the two groups were morphologically identical before treatment.

METHOD

Serial tracings were made by the writer from routine cephalometric radiographs taken before, and at the termination of, active treatment, the patients having been positioned in the cephalostat by members of the dental staff to ensure registration of the correct 'bite'. In certain Andresen cases, additional cephalometric radiographs had been taken during the treatment. In these circumstances, the two which approximated most closely to the duration of wearing the appliance were selected for study.

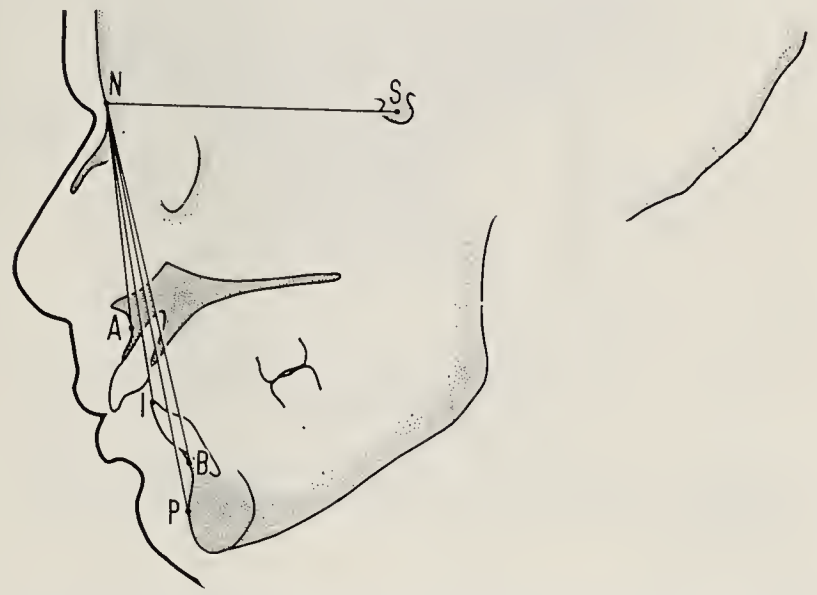

Fig. 1.—Diagram to show the points and angles used in the investigation.

Each radiograph was traced as in *Fig.* 1. The points A, B, sella, and nasion need no introduction. P represents the pogonion, and I the lower incisal tip at the point of intersection with the long axis.

The angles, SNA, SNB, SNI, and SNP were measured with a protractor. Due to the certainty with which the points could be identified, subsequent retracing of a random sample after an extended interval, and without knowledge of the original readings, revealed an accuracy to within half a degree. Coincident readings were obtained in at least 50 per cent of instances for each angle.

At the time of tracing the investigator was unaware to which group the case belonged in order to maintain impartiality.

As can be seen from *Table I*, the similarity between the two groups before treatment was

convincing, at least in respect of the angles under investigation.

The average age before treatment was 10 years 9 months for the Andresen group and 11 years 4 months for the control cases. The average duration of the treatment under study (that is to say the interval between the radiographs measured) was 3 years 2 months for each group. The cases showing an increase in ∠SNP in the present study is less than the 87 per cent claimed by Meach (1966), whose Andresen sample, incidentally, was most probably selected by clinical result.

A simple geometrical adjustment is necessary before we can mentally equate the angle changes during treatment with distances in millimetres.

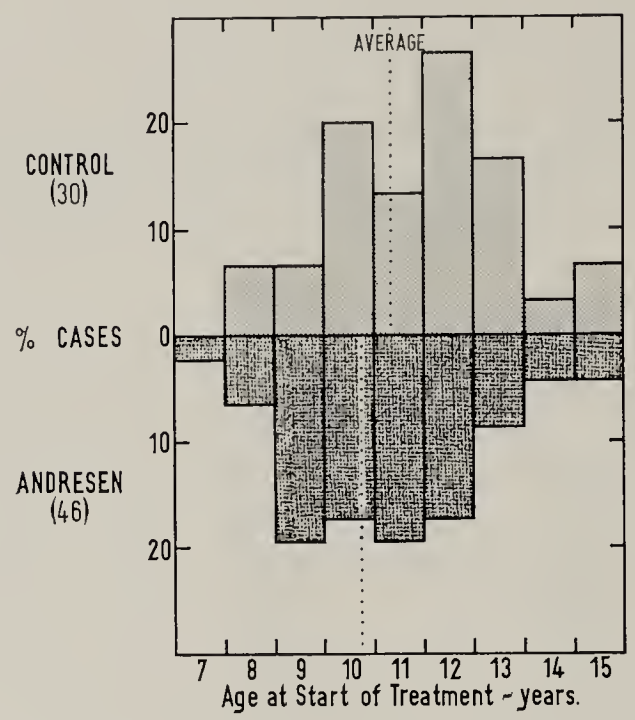

Fig. 2.—Histogram to show the ages of individuals in the two groups at the beginning of treatment.

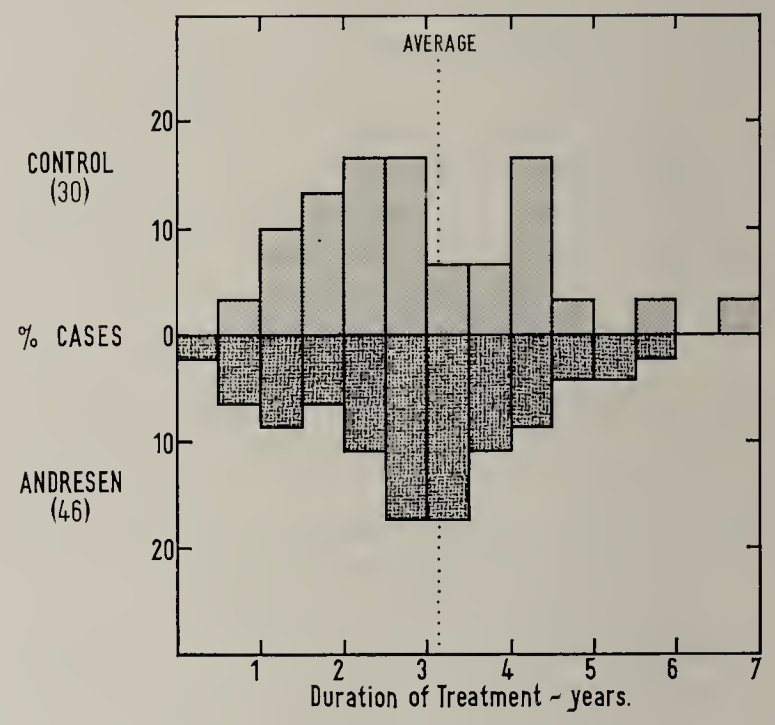

Fig. 3.—Histogram to show the duration of treatment in the two groups.

Table I.—Similarity of Groups before Treatment (Mean Values)

Angle	Andresen (46 cases, 59 per cent male)	Control (30 cases, 73 per cent male)
∠SNA	81·5°	81·9°
∠SNB	75·2°	75·5°
∠ANB	6·4°	6·4°
∠SNI	79·2°	79·5°
∠SNP	76·4°	76·5°

Table II.—Percentage of Cases showing Favourable Angle Changes during Treatment

Angle	Cases showing Increase (per cent)	
	Andresen	Control
−∠ANB	85	57
+∠SNB	76	57
+∠SNI	76	50
+∠SNP	76	70
−∠SNA	57	37

distributions of the initial age and duration are illustrated in *Figs.* 2 and 3 respectively.

The average period during which the Andresen appliance was in use was 1 year 9 months.

FINDINGS

Table II shows the percentage of cases in each group showing a favourable change in the angles measured. ∠ANB denotes the maxillo-mandibular relationship according to Downs's analysis. It is interesting to observe that 85 per cent of the Andresen group showed a favourable change in this angle, which is rather higher than the 76 per cent quoted by Moss (1962) in his series of successful Andresen results, although the 76 per cent of

With reference to *Fig.* 1 it will readily be understood that an angle change of 1° will be of greater significance at point P than at A, due to the greater vertical distance from N. In fact, a 1° change measured at point N is roughly equivalent to 1 mm. at A, 1·5 mm. at I, nearly 2 mm. at B, and over 2 mm. at P. Needless to say, these are approximate figures, estimated from a random selection of radiographs taken at the end of treatment, and do not take into account the slight enlargement of the radiographic image during cephalometric projection.

The Mandible

Looking first at the changes during treatment in the control group, it can be seen from *Table III*

that the chin point advances more than point B, the incisor tip the least. The corresponding Andresen figures (making allowance for the varying distances from point N) show that the actual forward movement of all three points is approximately the same.

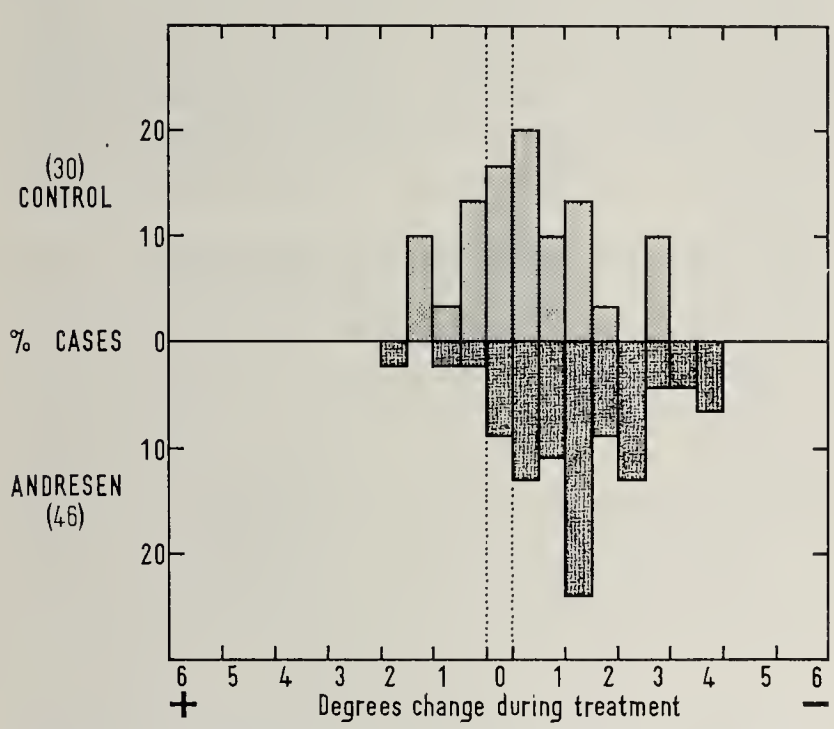

Fig. 4.—Histogram to show changes in ∠ANB in the two groups during treatment.

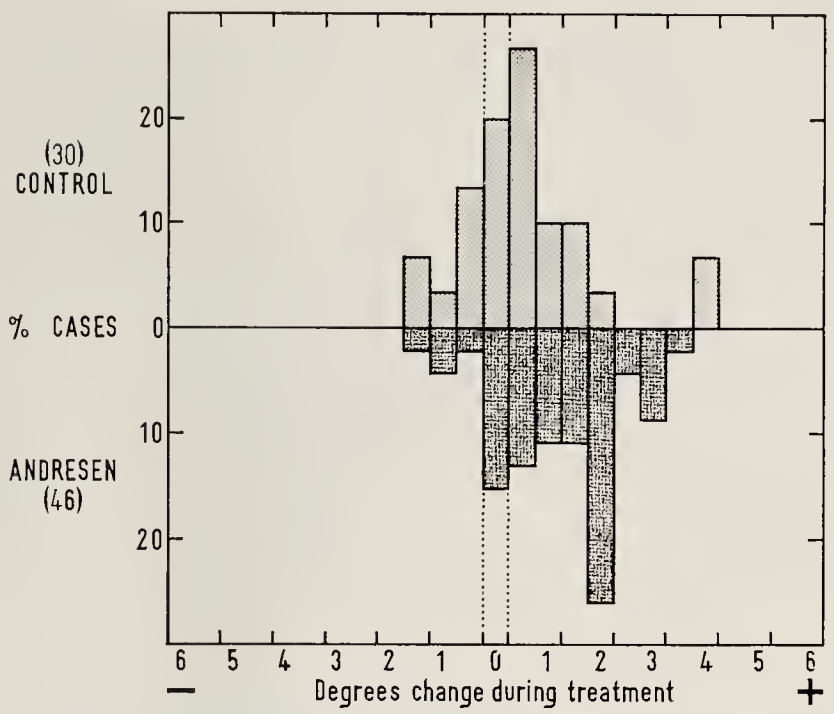

Fig. 5.—Histogram to show changes in ∠SNB during treatment.

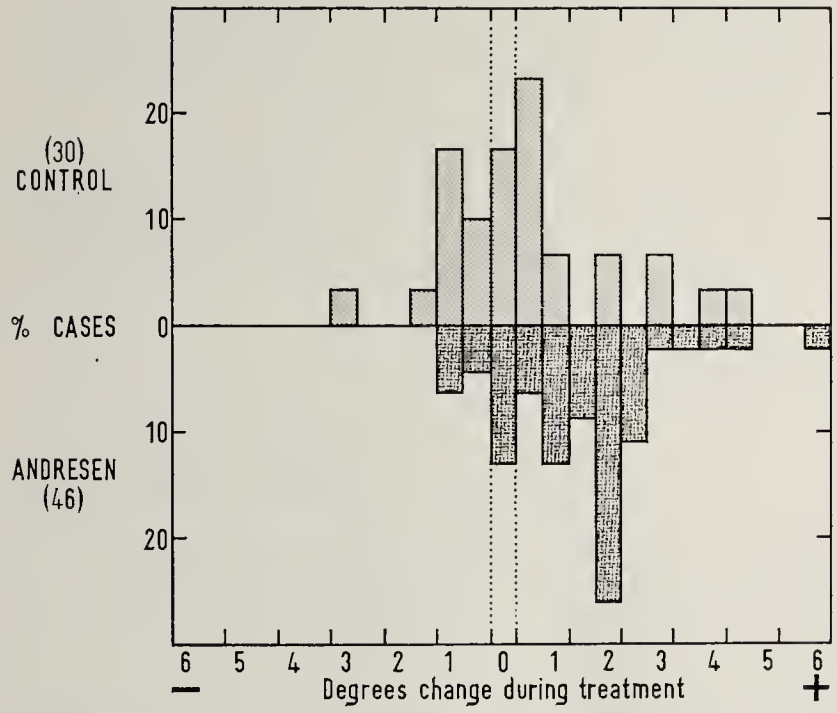

Fig. 6.—Histogram to show changes in ∠SNI during treatment.

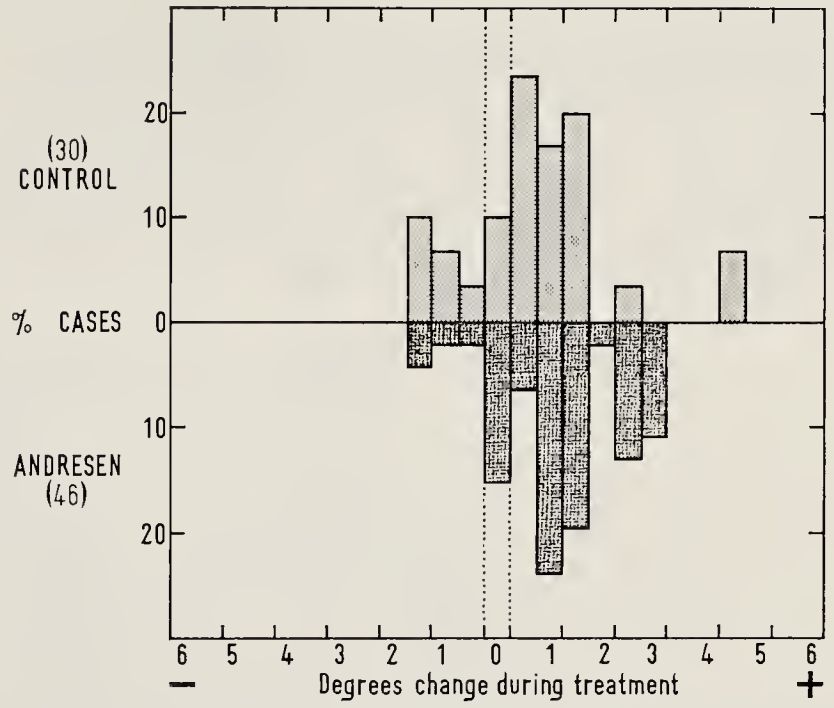

Fig. 7.—Histogram to show changes in ∠SNP during treatment.

Compared with the control group, therefore, the Andresen cases would seem to have gained some $1\frac{1}{2}$ mm. of forward movement at the lower incisal tip and point B. Both changes are statistically significant using Student's *t*-test, but clinically too small to warrant serious consideration.

Unfortunately an insufficient number of radiographs of cases out of retention were available to enable me to discover whether or not these changes remain stable. While it is dangerous to draw clinical conclusions from mean figures, the forward movement of the lower incisal tip in the Andresen group is scarcely greater than that which will remain stable following deliberate proclination with other appliances (Mills, 1966). In the present study the incisal inclination was not recorded, but the fact that point B advances with the lower incisor, and to a similar extent, suggests that the small forward movement of the incisal edge has been accompanied by alveolar remodelling. It is unlikely to have been achieved by proclination alone, particularly as the Andresen appliance is normally constructed with lower incisal capping and is deliberately left untrimmed lingual to these teeth. From personal clinical experience I am not convinced that the Andresen appliance gives rise to worse imbrication of the lower incisors than may occur naturally in lower arches unrelieved

by the extraction of premolars. This is supported by the findings of Miller (1967). Much, of course, depends on case selection.

Figs. 4, 5, 6, and 7 illustrate the angular changes as histograms. The distribution, particularly in *Fig.* 5 (∠SNB) and *Fig.* 7 (∠SNP) largely refutes the possibility that a minority

Fig. 8.—Histogram to show changes in ∠SNA during treatment.

of Andresen patients might have given a positive bias to the overall figures by posturing the mandible forwards in the cephalostat, producing a ' false bite '. Had such been the case, we would expect to find the main distribution of the two groups to be roughly coincidental, with a smaller second ' peak ' for the Andresen group towards the right of the histogram.

However, in the control group two cases can be seen to fall well to the right of the general distribution, with an increase in ∠SNB of no less than 4°. As the bites registered on the plaster models were consistent with the radiographs, it can only be assumed that an unusual pattern of growth has occurred. Had the cases been equipped with Andresen appliances, they might have provided powerful ammunition for the environmentalist cause.

The Maxilla

The histogram of ∠SNA change during treatment (*Fig.* 8) shows no significant difference, as already suggested by the mean figures (*Table III*). However, direct comparison between the two groups is less valid with reference to the maxilla than the mandible, since every case in the control group received appliance therapy in the upper arch, usually involving premolar extractions (63 per cent of cases). It will be recalled that in none of the Andresen patients were upper teeth extracted (excepting the second permanent molars).

Trayfoot and Richardson (1968) used a series of untreated controls in which the ∠SNA was found to increase by 1·26° over a variable period of between 6 months and 3 years. In the control group of the present study, it was thought likely that the extraction of upper teeth and the retraction of the upper labial segment might have prevented any naturally occurring forward movement of point A. In an attempt to exclude the possible effects of extractions, the control group was subdivided according to whether or not upper premolars had been lost during treatment. The results, which cover an identical time span, are shown in *Table IV*. The Andresen figure is included for comparison.

The difference in ∠SNA change between the control cases with and without extractions is not statistically significant ($P<0·1$), probably on account of the small sample size.

If we now compare the Andresen group with the control cases in which no upper premolars were extracted, we find that ∠SNA has decreased by an average of 0·73° in the former. This is still a very small change, equivalent to approximately 0·75 mm. and of little clinical consequence. Nonetheless it is statistically significant.

It would seem possible from these findings that a proportion of the improvement in point A claimed for the Andresen appliance by Trayfoot and Richardson, could have been effected by retraction of the upper labial segment.

Table III.—Mean Angle Changes during Treatment

Angle	Andresen		Control		Difference	Significance
	Mean	S.D.	Mean	S.D.		
−∠ANB	1·50°	1·31°	0·52°	1·25°	0·98°	$P<0·002$
+∠SNB	1·22°	1·18°	0·52°	1·26°	0·70°	$P<0·02$
+∠SNI	1·46°	1·45°	0·43°	1·63°	1·03°	$P<0·01$
+∠SNP	1·16°	1·17°	0·73°	1·44°	0·43°	N.S.
−∠SNA	0·28°	1·05°	0	1·03°	0·28°	N.S.

Initial Skeletal Disproportion

In order to investigate a possible relationship between the mandibular changes in the Andresen

cases and the severity of the initial skeletal disproportion, both groups were subdivided as follows: cases in which ∠ANB before treatment was less than the average for the group were classified arbitrarily as ' mild Skeletal II ', and those in which ∠ANB was greater than the average were classed as ' severe Skeletal II '.

The Andresen cases with the greatest initial disproportion showed twice the increase in ∠SNB compared with the mild Skeletal II cases (*Table V*). The difference is statistically significant ($P<0{\cdot}02$).

Even small mandibular changes become more valuable in the severe Skeletal II patient.

It is interesting that ∠SNP showed a similar relationship to the initial skeletal discrepancy as ∠SNB, which brings into question the possibility of growth changes in the severe Skeletal II group. However, as no statistical significance is demonstrable, we cannot be certain that the small improvement shown at the chin point in the Andresen patients is not due to chance. ∠SNA showed no relationship with skeletal discrepancy in either group.

Table IV.—Mean Change in ∠SNA during Treatment related to Upper Premolar Extractions in the Control Group

Group	Cases	∠SNA		Significance
		Mean	S.D.	
Control with upper extractions	19	−0·26°	1·02°	N.S.
Control without upper extractions	11	+0·46°	0·91°	
Andresen without upper extractions	46	−0·28°	1·05°	$P=0{\cdot}05$

The control group appears to follow exactly the same pattern. In this instance, however, the difference between the mild and severe cases is not statistically significant, on account of the inclusion within a small sample of the two patients referred to previously, in which ∠SNB has unaccountably increased by 4°. Both cases belong to the severe group. (Without these two cases, the mean figures for the control subgroups would be almost identical.)

For the same reasons there was no statistically significant difference within the severe Skeletal II patients between the Andresen and control cases ($P<0{\cdot}1$). However, from the fact that the increased forward movement of point B, compared with the mild cases, was fairly evenly distributed within the Andresen group, whereas in the control group it was confined almost entirely to 2 cases, it can be seen that the changes at point B in the Andresen patients are clinically more meaningful than the average figures suggest.

Table V.—Changes in ∠SNB during Treatment related to the Initial Skeletal Disproportion (Mean Values)

	Mild Skeletal II		Severe Skeletal II	
	Andresen (25 cases)	Control (15 cases)	Andresen (21 cases)	Control (15 cases)
Initial ∠ANB	5·14°	5·27°	7·81°	7·57°
Change ∠SNB	+0·84°*	0·20°	+1·67°*	0·83°
	(S.D. 1·06°)	(S.D. 0·92°)	(S.D. 1·19°)	(S.D. 1·50°)
Treatment time	2 years 11 months	3 years 4 months	3 years 4 months	3 years

*The difference between these two figures is significant ($P<0{\cdot}02$).

Duration of Andresen Therapy

As mentioned earlier, in several Andresen patients the appliance had been prescribed for only a small proportion of the time recorded on the cephalometric radiographs. Therefore it was decided to separate the Andresen cases into two groups, according to whether the appliance had been in active use for more or less than half the total treatment time. The result in terms of ∠SNB is shown in *Table VI*.

Contrary to what might be expected, the cases in which the Andresen had been worn for three-quarters of the total treatment time show negligible advantage, in respect of point B, over those in which the appliance had been used for only a quarter of the treatment.

This might be interpreted as support for the environmental suggestion of Marschner and Harris (1966), that once the genetically determined growth pattern has been restored, further growth will be no greater than normal. If this is

the explanation, the released growth potential would seem to have been quickly regained and small in amount. Personally, I am reluctant to ascribe changes seen at point B to growth rather than remodelling of the alveolus, while true basal bone changes measured at pogonion have not been proved with statistical certainty in this study.

Whatever the explanation of the small initial forward movement, the relative immobility of the lower arch during subsequent Andresen treatment probably reflects the excellent anchorage afforded by the mandibular teeth in this form of intermaxillary traction. It seems probable that the Andresen achieves the greater part of its clinical result by distal movement of the upper teeth within the maxilla.

Table VI.—Changes in ∠SNB during Treatment related to the Duration of Wearing the Andresen Appliance (Mean Values)

Andresen worn for	Time worn	Treatment Time	Change in ∠SNB
76 per cent of treatment time	2 years 3 months	2 years 11 months	+1·27°
28 per cent of treatment time	1 year	3 years 7 months	+1·13°

Patient Co-operation

Since the selection of cases for this paper did not depend upon clinical success, it may be assumed that a proportion of the patients were at least partially uncooperative. In the Andresen group it seemed conceivable that such cases might detract quantitatively from the overall changes demonstrated.

Accordingly an attempt was made to assess the co-operation of each Andresen patient. Reference was made to the operator's comments in the case records, and each patient was classified as ' good ' (favourable comment or ' no comment ') or ' bad ' (unfavourable comment). Twenty-six per cent of the Andresen cases belonged to the latter category. ∠SNB was selected for investigation.

The results in *Table VII* favour the co-operative group less than might be anticipated, but this may be a reflection, at least in part, of the difficulty in forming a retrospective estimation of co-operation from case sheets written up by different operators. Even when confronted with live material in the clinic, it is not always easy to ascertain which Andresen spends the night in the mouth, and which under the pillow.

Table VII.—Changes in ∠SNB during Treatment related to Co-operation of Andresen Patients (Mean Values)

Andresen Co-operation	No. of Cases	Treatment Time	Change in ∠SNB
Good	34	3 years	+1·3°
Bad	12	3 years 7 months	+1·0°

The Age Factor

It has been claimed that the Andresen is most effective when used in the ' active growth phase '. However, regular cephalometric X-rays at short intervals are required for an investigation of this kind, in order to be able to record growth increments. Unfortunately the extended interval between radiographs in this study prevented precise conclusions being drawn as to the timing of the changes shown. It is possible only to say that the most favourable changes relating to ∠ANB in the Andresen group fall within the age range 10–14 years.

Sex Incidence

Although the sex ratio differed between the two groups under study (*Table I*), the changes demonstrated showed no correlation with sex.

SUMMARY

Over a period of 3 years 2 months, patients treated with an Andresen appliance showed a favourable change of approximately 1½ mm. at point B and the lower incisal tip. The change in point A was less marked (0·75 mm.). These 3 changes are statistically significant but insufficient in themselves to justify use of this appliance over another. There is evidence to suggest that the extent of the mandibular changes may be increased to the point of some clinical value in cases with a moderate to severe Class II dental base relationship. Even in these cases, however, the changes at chin point are not statistically significant, possibly on account of the small numbers involved.

No harmful effects were noted in the lower arch such as might prejudice stability or promote

a relapse of any magnitude. The results in respect of the landmarks studied did not appear to be related to the duration of Andresen therapy, age, or sex factors.

Acknowledgements

I would like to express my appreciation to Dr. W. Grossman for allowing me access to the departmental records. I am most grateful to Dr. J. R. E. Mills, also to Mr. J. P. Moss and Professor D. C. A. Picton for their help and advice. I am indebted to Dr. I. Sutherland of the M.R.C. Statistical Research Unit, to Mr. V. K. Astor the hospital artist, and Mr. C. R. Day, the hospital photographer, for their expert advice.

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DISCUSSION

Dr. J. R. E. Mills pointed out that there had been a number of investigations on the subject over the past few years and since the symposium which the Society held some years ago. Many of them suffered from unsatisfactory controls, but nevertheless there seemed to be a pattern, and it was necessary to face the fact that the Andresen appliance caused slight changes in point A and point B. The question whether any difference was made to chin point was much more controversial. In Dr. Mills' view those concerned were to some extent hoist with their own petard, because of the myth in orthodontics that the jaws were divided into basal bone and alveolar bone. It should be borne in mind that nearly all of the jaws had been alveolar bone at some time, but this had been absorbed into the basal bone.

Another myth that had been propagated was that point A and point B were basal points. Indeed they were not really points at all. If one compared point B now with point B of 3 years ago, it would be found to be a little higher up. Therefore there would be some modification of those points. That had been shown clearly in the United States in treatment involving posterior movement of the upper teeth including incisors. Nevertheless, Dr. Mills still felt that the changes were so small as to have no appreciable effect on the occlusion. It was important to realize that the vast majority of the movement which took place was movement of the teeth.

Mr. Parkhouse, in reply, agreed with Dr. Mills' comments concerning the basal and alveolar bone.

Points A and B had come under a great deal of fire lately. Mr. Parkhouse said he felt safe in using them only because he was using two groups, so that his conclusions were comparative rather than absolute.

The statement that Dr. Mills had made in the symposium referred to previous investigations which, at that time, had been few in number. It would seem from this and other recent papers that his original statement was very much justified, in that the changes are minor and in the main clinically inconsequential. The only modification that the author might suggest was that the changes were not entirely unpredictable, inasmuch as the severe skeletal cases showed them more frequently than the mild ones.

Dr. Mills said he thought he was right in saying that Björk found that severe Class II skeletal cases tended to show more favourable skeletal change, in the absence of any treatment, than did more normal skeletal patterns.

Mr. Parkhouse, in reply, said that Björk investigated a large series of Swedish children and found it in a proportion of them.

Mr. C. P. Adams felt that Mr. Parkhouse probably did himself less than justice when he emphasized how small the changes were. It was Mr. Adams's belief that the changes although small were significant. The trouble was that the changes were so small that it was difficult to analyse them sufficiently accurately. The kind of research discussed this evening would have to go on until some kind of pattern emerged as to what happened to the shape and size of the jaws when changes in the occlusion took place.

It was well known how widely the shape of the face could vary consistently with the normal arrangement of teeth and to expect very large changes in face shape and relationship corresponding to the changes that took place in occlusal relations as a result of treatment was unreasonable. Changes in face shape were probably produced also but they were small and hard to detect.

Mr. Adams agreed with Mr. Parkhouse about the importance of getting X-rays accurately taken, and it would be interesting to hear how he managed to get his staff to see the films being taken. Mr. Adams wished he could get his own staff to supervise the positioning of the patient for cephalometric radiography.

On the question of the size of the changes being measured, it would be interesting to learn whether Mr. Parkhouse made any check on the accuracy of the method of measurement. To leave out that important step militated against the validity of the results and there were no mitigating circumstances for omitting it in the procedure.

Mr. Parkhouse, in reply, agreed with Mr. Adams, although he felt particularly flattered that Mr. Adams should think of him as having a staff! It had been the practice for members of the orthodontic department at University College Hospital to take their own

cephalometric X-rays for as long as he could remember.

As for the question of the accuracy of measurement, he was fortunate in having clearly defined radiographs and it was, of course, much easier to measure an angle made between three widely separated points than, for example, to measure the inclination of a lower incisor to the mandibular plane. In a double determination the tracing error had consistently been to within half a degree. Where there was doubt as to whether a half degree should be recorded, he always went against a positive change. In other words, in the first tracing he would, in cases of doubt, be biased in favour of normality, and away from normality in the second trace.

Since there had been no partiality, the tracing errors would have been distributed evenly between the two groups. This would have had the effect of increasing the standard deviations, thereby making statistical significance less easy to demonstrate.

Mr. C. D. Parker asked how long the cases were out of retention. From his own work he had found that the fitting of an Andresen or similar appliances altered the vertical relationship of the jaws and because the mandible hinges approximately around the condyles, horizontal changes also occur. Following the removal of appliances, further vertical changes occur and therefore it was of considerable interest to know when the appliances were discarded.

Mr. Parkhouse, in reply, said that none of the cases in the series had been investigated out of retention. It had been a question of making the best of the material available to him and it was disappointing that the number of X-rays of patients out of retention was too small to merit investigation. It would be interesting to know, for instance, whether Moyers was right in his contention that subsequent natural growth occurring after Andresen therapy might ' absorb ' the changes shown.

He could not say that he had noticed any change in the vertical relationship following retention in Andresen patients, except in Class II, division 2 cases in which there was, as might be expected, some relapse in overbite.

POST-TREATMENT ANALYSIS OF ANGLE CLASS II, DIVISION 1, AND CLASS II, DIVISION 2 MALOCCLUSIONS IN A PAIR OF IDENTICAL TWINS

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Much interest has been focused in the orthodontic literature on apparently identical twins who show differences in the degree and type of malocclusion. Leech (1961), among others, has described such a pair of twins, the one with an Angle Class II, division 1, and the other with an Angle Class II, division 2 malocclusion. The author has also described a similar pair of twins (Briggs, 1963). They were examined fully both clinically and cephalometrically, and also investigated on the electromyograph for which I am indebted to Mr. Richard Marx. A blood investigation of the twins together with their mother was performed (*Table I*) and, to quote the haematologist's report, these results were ' entirely consistent with identical twinning '. I offer these case histories to you without any claims for originality or excellence either in treatment or in result, hoping, however, that you will find the long-term results of some interest.

Table I.—Haematological Report showing Evidence of Identical Twinning

	Blood Group ABO	Rhesus Factor						
		Rh	MN	Phenotype Genotype	Probable	Pl.	Kell Antibodies	Duffy
Mrs. C.	AO	Pos.	MM	$CCD\overline{ee}$	R_1R_1	P^{++}	K^-	Fy^{a-}
H.C.	BO	Pos.	MM	$C\bar{c}D\overline{ee}$	R_1r	P^+	K^-	Fy^{a-}
J.C.	BO	Pos.	MM	$C\bar{c}D\overline{ee}$	R_1r	P^+	K^-	Fy^{a-}

This is entirely consistent with identical twinning

CASE REPORT

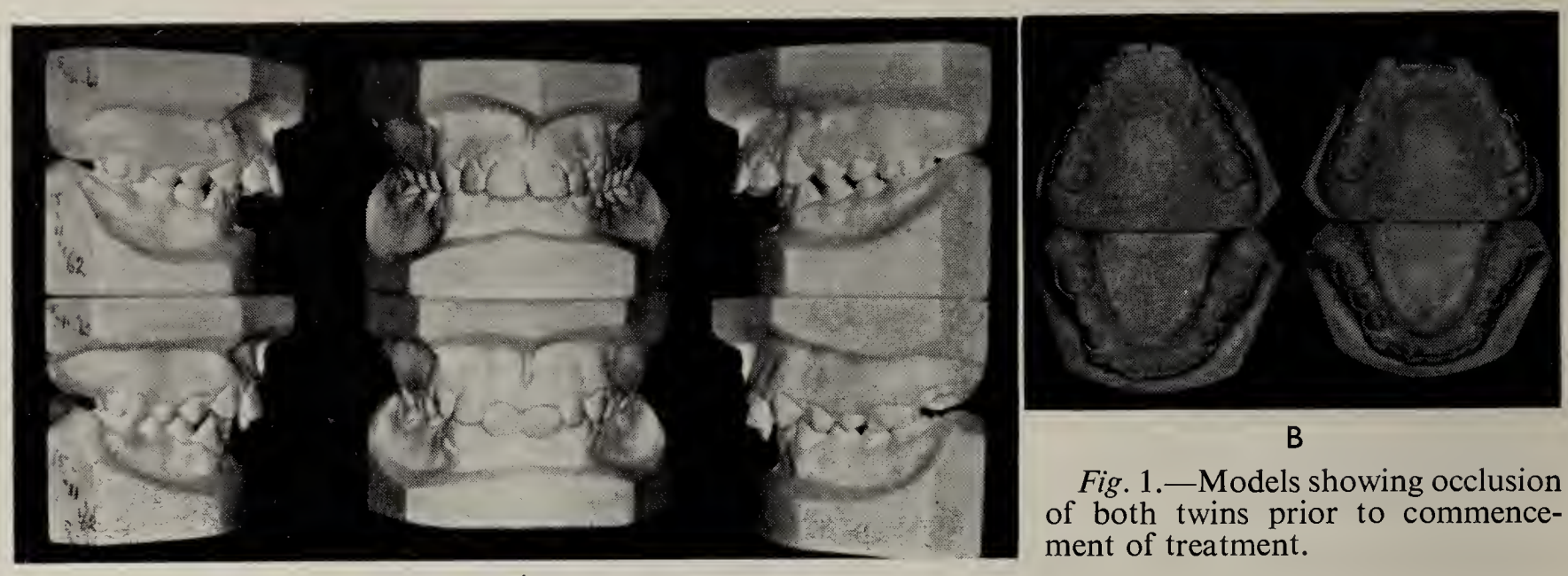
Clinical Analysis

Twin H.C. is the Angle Class II, division 1, and twin J.C. the Angle Class II, division 2. The models of the malocclusions are shown (*Fig.* 1). The girls were 9 years of age at the commencement of treatment in January, 1963. The clinical analysis (*Table II*) showed that the swallowing action in both children was normal and the lip morphology slightly incompetent, but in the Class II, division 1 case the lips were separated by the upper incisors. The path of closure was centric at all times and there was no evidence, either then or since, of a forward resting posture in the Class II, division 1 case. This was confirmed at the time by the electromyographic analysis. It was felt significant at the time that the Class II, division 1 twin, H.C. had sucked her right thumb for many years and still did at the time of first examination; the Class II, division 2 twin, J.C., had never sucked either a thumb or finger. The skeletal morphology of both twins has always been remarkably similar, and the most recent tracings superimposed (*Fig.* 2A) demonstrate how similar these two children are. When the original tracings are compared the similarity is again seen (*Fig.* 2B).

Treatment for the Twin H.C., Class II, Division 1

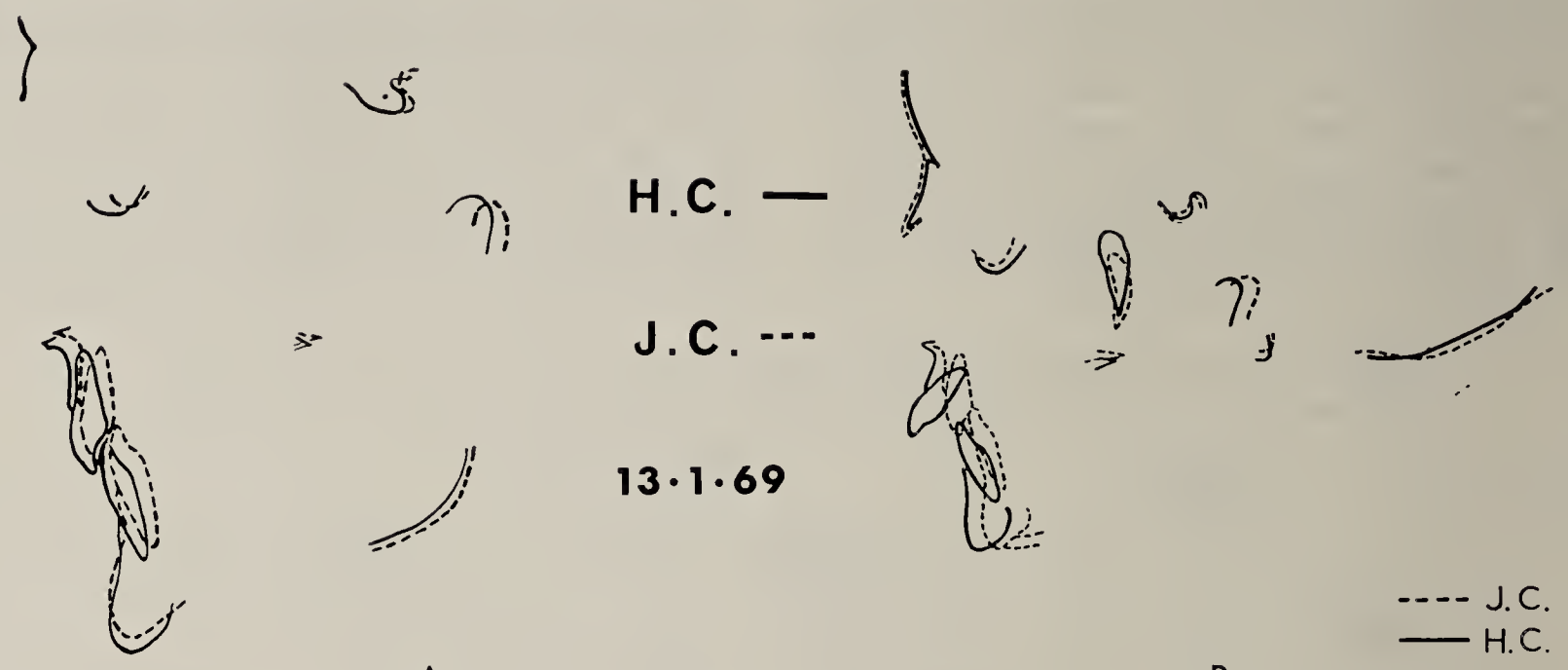
As $\lceil\overline{6}$ was heavily filled and hypoplastic it was decided to extract $\overline{6|6}$ and $\underline{4|4}$. Upper removable appliances combined with extra-oral traction by means of a head cap were fitted, but progress was slow. It was not until September, 1963, when an upper fixed appliance with a palatal arch and finger springs of the Rix type were fitted, that canine retraction was seen to proceed satisfactorily. No treatment was instituted

Presented at the meeting held on 10 March, 1969.



A B

Fig. 1.—Models showing occlusion of both twins prior to commencement of treatment.



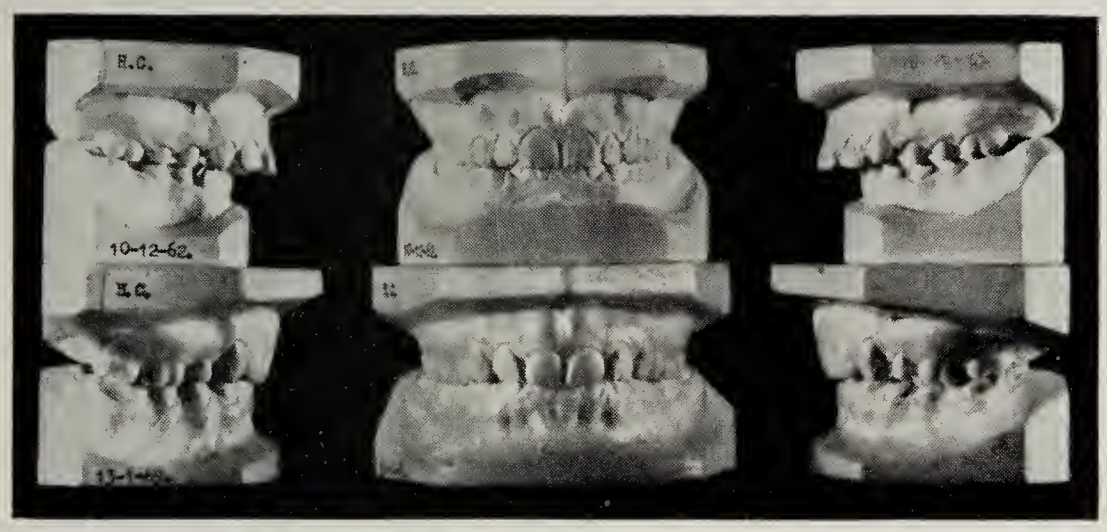
A B

Fig. 2.—Superimposed lateral skull tracings of both twins. A, Three years out of retention; B, Prior to commencement of treatment.

Table II.—Clinical Analysis of Both Twins Prior to Commencement of Treatment

Clinical Analysis	Twin H.C.	Twin J.C.
Frankfurt/mandibular plane angle	Average	Average
Upper incisors	Proclined and spaced	Retroclined $\underline{1\|1}$ and crowded
Lower incisors	Normal inclination crowded	Slightly retroclined and crowded
Skeletal classification	Skeletal II	Skeletal II
Occlusal classification	Class II, division 1	Class II, division 2
Lip	Slightly incompetent, separated $\underline{21\|12}$	Slightly incompetent, habitually together
Lip-line	Behind $\underline{21\|12}$	High—above level of occlusal half
Swallow	Cheek teeth together, no tongue thrust	Cheek teeth together, no tongue thrust
Path of closure	Central	Central
Resting posture	Forward	Forward
Habits	Sucks right thumb	Nil
Overbite	Increased complete	Increased complete

in the lower arch but it will be seen that the lower second permanent molars drifted forwards spontaneously into an excellent position, and the most recent photographs (*Fig.* 3A) show these teeth in good occlusion with the lower third permanent molars was placed in position and subsequently replaced by a round-wire working arch, 0·45 mm. (0·018 in.) diameter, incorporating box loops to push $\overline{3|3}$ distally. In the upper arch a removable appliance was fitted to retract $\underline{3|3}$ at the same time 'depressing' the lower



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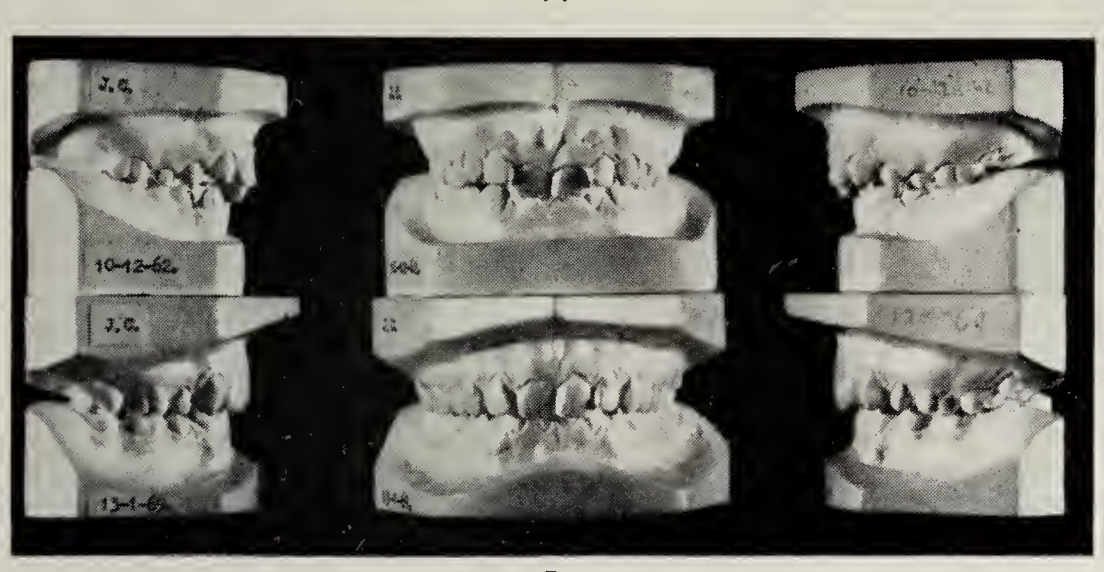

B

C

Fig. 3.—A, Lateral and anterior views of models of twin H.C. (Class II, division 1) prior to treatment and three years out of retention. B, Similar views of models of twin J.C. (Class II, division 2). C, Occlusal views of the same models of both twins.

Table III.—Cephalometric Analysis of Both Twins taken before Treatment and Three Years out of Retention

Cephalometric Analysis	Twin H.C.		Twin J.C.	
	10 *Dec.*, 1962	13 *Jan.*, 1969	10 *Dec.*, 1962	13 *Jan.*, 1969
S.N.A.	77·5	75·0	74·5	72·5
S.N.B.	73·0	71·0	70·0	70·5
S.N.A./S.N.B. difference	4·5	4·0	4·5	2·5
Maxillary/mandibular plane angle	26·5	23·0	27·3	23·0
Frankfurt/mandibular plane angle	23·8	20·0	26·1	21·0
Upper incisor/Frankfurt plane angle	127·3	88·0	89·3	92·0
Lower incisor/mandibular plane angle	88·5	86·0	83·8	85·0

erupting into an extremely pleasing position. All appliances were withdrawn in March, 1966, since when there has been little change in the occlusion.

Treatment for the Twin J.C., Class II, Division 2

Treatment was commenced by extracting all four first premolars. Bands were cemented in the lower arch in February, 1963, and a light wire alining arch incisors. A further removable appliance was fitted in July, 1963, to aline the upper lateral incisors, and in August, 1963, intra-arch traction in the lower arch was applied to aline the lower incisors and close residual premolar spaces.

It was found in the beginning of 1964, that the upper buccal segments were tending to come forwards and removable appliance therapy was required to

correct this. Treatment proceeded without interruption and in September, 1965, all appliances were withdrawn.

It will be seen in the post-retention models (*Fig.* 3B) taken on 13 January, 1969, that whilst the lower arch has retained satisfactorily apart from very slight crowding in the lower right lateral incisor region, the upper labial segment, though much improved has not retained quite so well. The upper left lateral incisor is tending to procline and the central incisors show definite signs of overcrowding (*Fig.* 3C). The axial inclination of the central incisors was left untreated but they have apparently proclined 2·7°.

Cephalometric Analysis

The lateral skull tracings reveal the comparative figures for the two twins (*Table III*) and the improvement in the incisor angulation will be noted.

DISCUSSION

This pair of cases demonstrates once again the different prognoses in a Class II, division 1, and a Class II, division 2 case. Twin H.C. was a quite severe Angle Class II, division 1 case, and yet the upper arch has remained extremely stable following treatment. The lower first permanent molars were extracted at an ideal age and the remaining molar teeth have erupted spontaneously into an extremely satisfactory position. The changes in incisor inclination (*Fig.* 4A) before and after treatment and 3 years out of retention are shown.

The Angle Class II, division 2 twin, J.C., was not a very severe case and yet in spite of careful treatment particularly in the lower arch, both upper and lower incisors are showing some deterioration 3 years out of retention. The upper central incisors, however, remain in good position (*Fig.* 4B). The difference in these cases following retention is interesting because one would expect little difference after treatment in 2 children who are otherwise so similar.

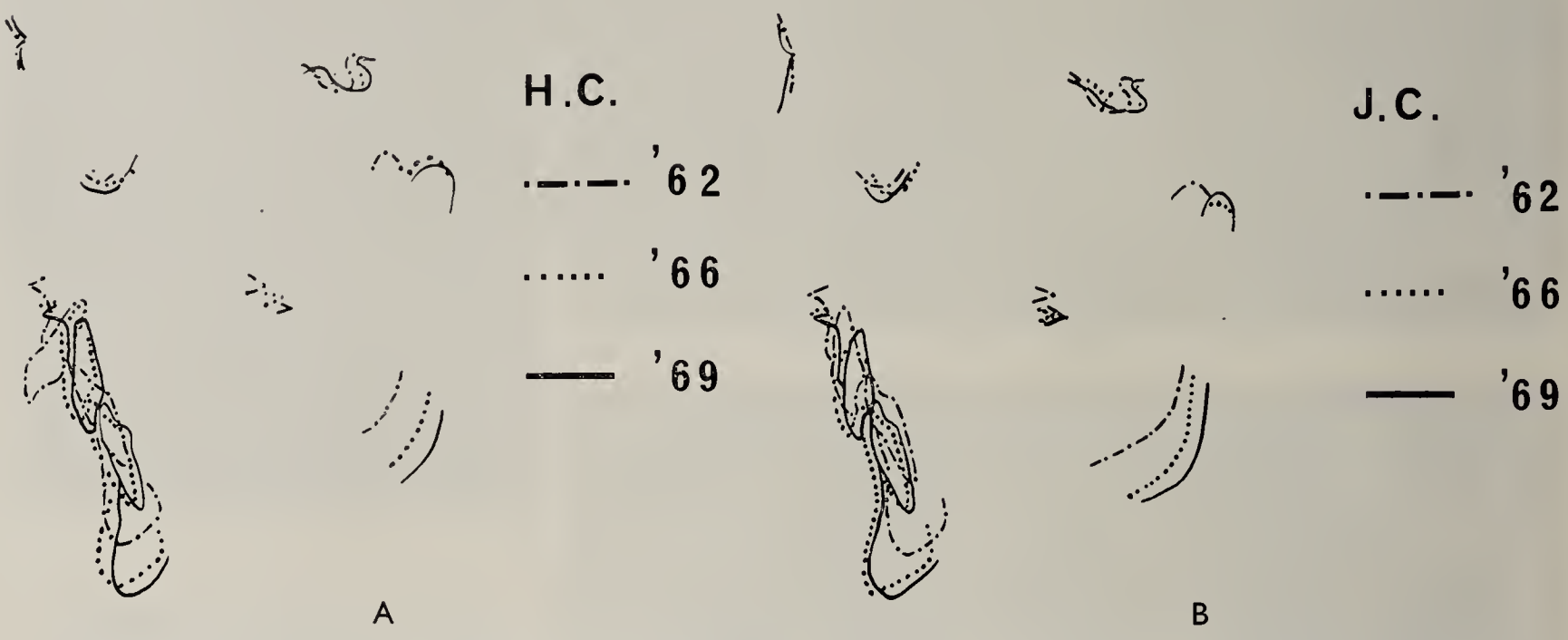

Fig. 4.—Superimposed lateral skull tracings before treatment, at termination of treatment, and three years out of retention. A, Class II, division 1 twin, H.C., B, Class II, division 2 twin J.C.,

Acknowledgements

My thanks are due to Prof. D. P. Walther for allowing me facilities to examine these patients; to the Photographic Departments of the Royal Dental Hospital, and the Coventry and Warwickshire Hospital, Coventry; and to the Dental Laboratory of the Coventry and Warwickshire Hospital, for photographs and technical assistance. Finally I should like to thank warmly the patients and their parents for their kindness and enthusiasm in allowing me to follow their progress over many years whilst collecting material for this paper, and elsewhere.

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DISCUSSION

Mr. G. H. Roberts asked Mr. Briggs whether he had any theories as to why the Class II, division 2 case had relapsed as much as it had.

Mr. Briggs, in reply, said he did not think he could draw any firm conclusions regarding that matter. It must be common knowledge that lateral incisors did tend to relapse even although they were retained for a considerable time afterwards. The child in question was retained for 8 months following completion of the treatment. It was only in the last year that relapse had been so noticeable on the lateral incisors.

Mr. H. L. Leech said he had treated similar identical twins some 10 years before the case referred to by the

author, and Mr. Briggs might be interested to know that Mr. Leech's Class II, division 2 case relapsed also, despite the fact that it was treated with the Begg multiband technique. The relapse in that particular case was not a relapse of crowding but of overbite. Mr. Leech used a torqueing action on the upper incisors moving their roots palatally, and at the same time he reduced the crowding with extractions. Three years after the end of treatment the crowding was still relieved, but the overbite had relapsed quite considerably.

There was one question with regard to the aetiology of the malocclusion. It was noticed that here the Class II, division 1 case sucked her thumb which might explain her incisor relationship, but in his case neither of the twins sucked her thumb. The only member of the family who sucked his thumb was a brother who had perfectly normal occlusion!

Mr. Briggs, in reply, said it represented an interesting difference in comparative results. He was quite surprised when he saw how well in the division 2 case the overbite had maintained its improved position. The only difference he could find in his original clinical examination was the matter of thumb-sucking but it would be foolish to draw firm conclusions from one case.

CINEDOTS: A NEW METHOD OF CINERADIOGRAPHIC ANALYSIS

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To describe orthodontics as a 'science' may possibly satisfy our professional ego. To actually believe this assertion, however tempting it may be, is difficult for any objective and experienced clinician. Even the best orthodontist must explain the reasons for his failures and relapses.

Whilst there has been a great leap forward in the field of precise and controlled tooth movement, confusion and controversy still surround the basic biological foundations of our craft.

The oft-quoted pendulum continues to oscillate between the protagonists of soft tissues and the skeletal 'morphologists'. In the United States and even in this country, where Begg and Edgewise technologists are ever increasing in their numbers, biological principles are often completely abandoned in favour of treatment planning based on pure geometry.

It is a well known fact that the sum of the four angles of any quadrilateral is equal to 360°. This, however, does not constitute a scientific rationale for clinical practice—not even if the quadrilateral *is* constructed from a cephalometric tracing.

Aristotle said, 'Science *is* measurement'. If at all possible, observation, classification, and hypothesis must, therefore, follow the accumulation and systematic evaluation of measurable data, and not precede it, as has been the case in our field.

Modern research tools, besides cephalometrics, have already made significant contributions.

Structural variations, especially of the radio-opaque variety, are more amenable to measurement than those pertaining to the functional aspects of the orofacial complex.

Devices such as the electromyograph and the more sophisticated pressure measuring instruments are useful. Their main disadvantage, however, lies in the fact that they all record effects produced by functions, rather than the actual functions being studied. A further disadvantage of such studies is the inability of the researcher to record a sufficiently large number of simultaneous and related functional phenomena at the same time.

Finally, the crux of the orthodontic problem is the need to find consistent associations between individual variations in morphology and the physiological adaptations in function, with which such variations seem to be so intimately related.

The ideal answer may still lie in the remote future. However, with our present resources, the best approach to an integrated study of the relationship of structure and function seems to be a combination of cephalometrics and high-speed cineradiography.

The development of image intensification, has rendered cineradiography a safe diagnostic procedure.

Increasing numbers of references in the literature show that this is now an established method for recording such functions as swallowing, mastication, and speech.

During the past 5 years the author's work has mainly been concerned with the variations in orofacial morphology and the associated patterns of behaviour in the articulation of certain speech sounds in normal subjects.

Björk (1961), Cleall (1964), and Vig (1968) have found that the soft palate, tongue, and hyoid are capable of very rapid movement. Therefore, to record extreme positions of these structures during function, it is necessary to use a high-speed cine-camera. Most cameras suitable for cineradiography have a maximum speed of 50–64 frames per second.

Using such equipment, it is, therefore, evident that a film sequence of as little as 10 seconds, duration will yield between 500 and 640 frames. Each frame possibly represents a different position of, and relationship between, the various structures under consideration. Recordings of such short duration, even in a small sample of 20 subjects, will yield over 10,000 frames for analysis.

A considerable advantage of such recordings, which has sometimes been overlooked, is that they provide an opportunity for the study of movement patterns in both the horizontal and the vertical planes.

Presented at the Research Meeting held in Leeds on 10 April, 1969.

Furthermore, the simultaneous analysis of several structures' behavioural characteristics, enables both their qualitative and quantitative relationships to be determined. The information content of each frame is, therefore, quite considerable. In other words, if conscientiously done, a frame-by-frame analysis would require a number of separate measurements per frame. For example, taking only 5 points per frame, there will be 10 separate measurements, 5 in the horizontal and 5 in the vertical. Getting back to our small sample of 20 cases, this in turn must be multiplied by a factor of 10,000 or more to give an idea of the work involved in the collection of the data. We are now contemplating something like 100,000 measurements.

In the past, investigators faced with this problem, namely a surfeit of material, have adopted one of two alternatives. The first and more common procedure was the purely subjective evaluation of films, with little or no attempt being made to measure variations in movement. More recently Sloan, Ricketts, Bench, Hahn, Westover, and Brummett (1964) have recommended the application of cephalometric principles to the analysis of individual frames. This means tracing each frame. In studies of swallowing, the problem of the large number of frames was overcome by selecting specific frames, to show typical positions during function.

Cleall (1964), for example, takes 5 representative frames, one for each stage of swallowing. In the study of speech, however, there are two main objections to this method of analysis. Firstly, the selection of 5 frames out of 500 per subject seems a great waste of the available information on the integrated function of the oral structures. To all intents and purposes the other 495 frames are redundant.

Secondly, from recent work on speech (Vig, 1968) it has become apparent that typical positions do not in fact exist in speech. The reason for this is as follows.

If one observes the movement of just one structure, say the tongue, it is possible to define a ' typical ' or representative position for a single vowel or consonant. For argument's sake, one may take the frame in which the dorsum of the tongue reaches its highest or lowest point.

The same can be done if another structure, such as the soft palate or the hyoid, is considered independently.

Unfortunately, it was found that taking all these structures together, their positions of maximum excursion from their starting position did not coincide in time. In other words, they arrived at these points at different frames and in a different sequence in different members of the sample.

For these reasons it was necessary to devise a new method for the quantitative analysis and description of movement patterns in speech.

METHOD

Prior to cineradiography, each subject had a standard cephalometric lateral skull radiograph taken with the teeth in occlusion. These radiographs were traced as shown in *Fig.* 1. Measurments of various morphological features were made. Some of these results have been presented elsewhere (Vig, 1968).

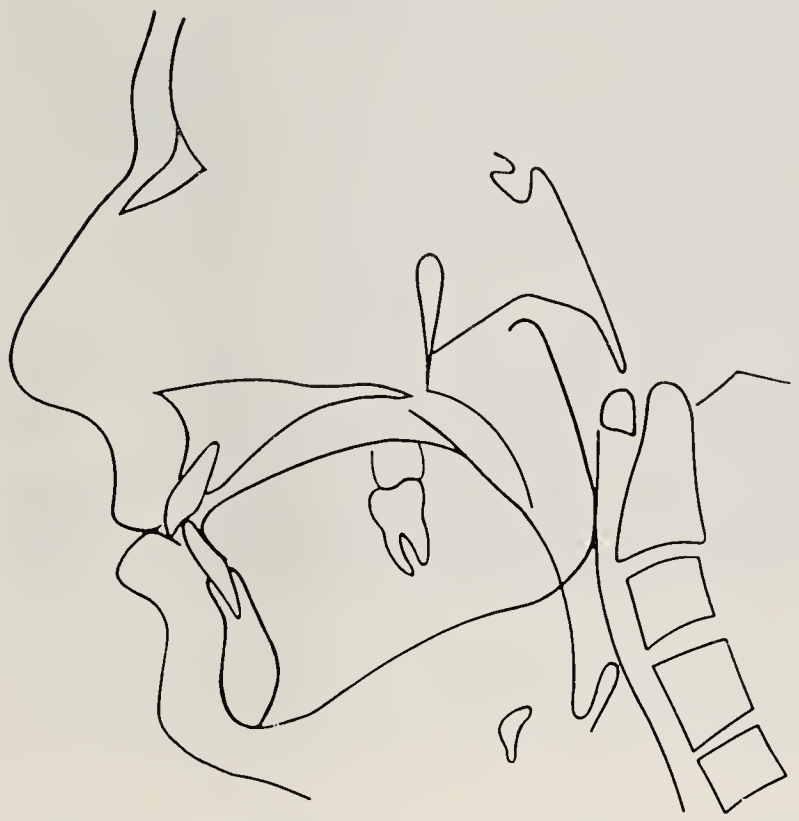

Fig. 1.—Tracing constructed from a cephalometric radiograph.

The description of the method relating to the cineradiographic aspect of this study will be described under the following headings:—

a. Instrumentation.
b. Procedure.
c. Analysis.
d. Reliability of the method.

Instrumentation

Fig. 2 shows the instrumentation used in obtaining the cineradiographic records. Image intensification was achieved by the use of a 7-in. Siemens electronic image intensifier. A Bolex H16, 16-mm. cine-camera was used at a speed of 64 frames per second. The film used throughout was Eastman Kodak Double-X Panchromatic Negative Safety film (type 7222), which was developed in a Kodak X-Omat Developer for 1·5–2 minutes at 80° F. (27° C.). To improve the visualization of the soft tissues a contrast medium was used. A diluted barium suspension, Microtrast, was applied to the dorsum of the tongue and down the middle of both lips using a fine paintbrush.

Radiation exposure of the patient is a most important factor in cineradiography. A number of factors such as the duration, film speed, type of X-ray source, and exposure values affect the total radiation dose. In addition to these, there is also the consideration of the duration of ' screening '

which is needed to line up the central beam of the X-ray source. Screening, which was carried out with a low mA. and kV. was necessary to ensure that all relevant movements in speech were clearly visible in the field of the image intensifier.

Radiation was monitored by attaching an ionizing chamber type dosemeter to the ear-post

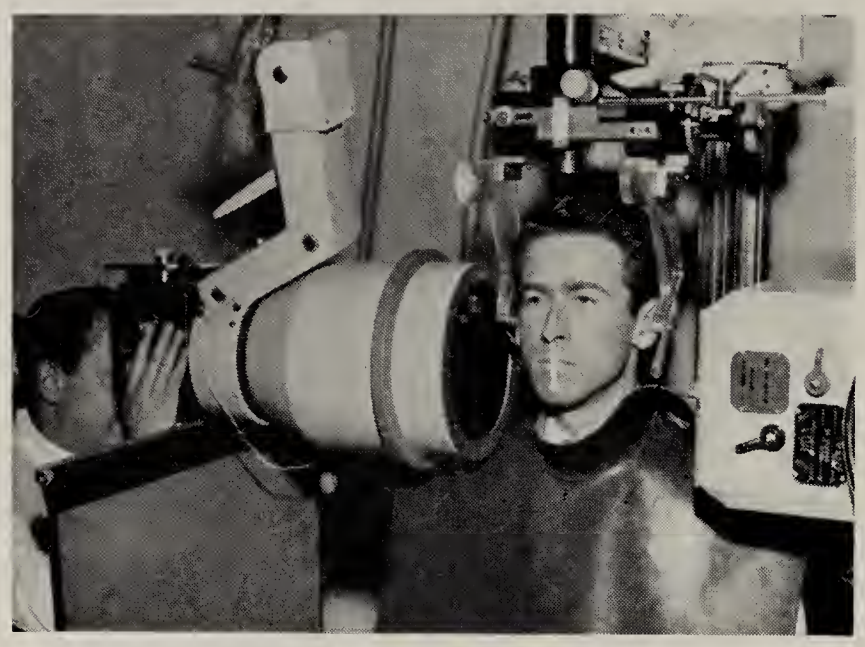

Fig. 2.—Instrumentation used in cineradiography. From left to right: operator, cine-camera, intensifying screen, subject in cephalostat, radiation dosemeter attached to left ear-post and X-ray source.

of the cephalostat so that the ionizing chamber was in the path of the incident X-rays.

After some preliminary trials, the most suitable combination of exposure values for filming was found to be 12 mA. and 75 kV. The average dose measured for 30 sequences of cineradiography was 0·9 r with a range of 0·2–2·1 r. These figures are similar to those reported by Timms (1962) and are of the same order as one lateral skull radiograph.

It should be pointed out, however, that the radiation thus measured in roentgens, is an estimate of skin exposure only, since secondary emissions produced by scatter from the skeletal and dental structures could not be assessed.

Procedure

After positioning the subject in the cephalostat and having alined the X-ray tube and intensifier, the test sequence was rehearsed.

Six separate, sustained utterances were studied. These were O, SO, THO, EE, SEE, THEE.

Viewing on the image-intensifier's monitor ensured that in extreme excursions of the mandible and hyoid these structures were not outside the range of view.

On command from the operator, the subject commenced the following test sequence which was recorded by the cine-camera.

1. Start with the teeth in occlusion.
2. Articulate O.
3. Teeth together.
4. Articulate SO.
5. Teech together.
6. Articulate THO.
7. Teeth together.
8. *Pause*. During this the camera was rewound and the radiation exposure monitored.
9. Teeth together.
10. Articulate EE.
11. Teeth together.
12. Articulate SEE.
13. Teeth together.
14. Articulate THEE.
15. Teeth together.

Each subject was recorded once. The first 10 were recorded on a second occasion which varied from immediately after, up to 6 weeks after the initial recording.

The test sequence varied in duration from 10 to 15 seconds, which at 64 frames per second yielded about 700–1000 frames for each recording.

Analysis

Before devising the method, the films were subjectively studied using slow-motion projection and tracing of individual frames. As a result of this it was noted that particular points on the mandible, hyoid, and tongue described paths of movement which were similar throughout the

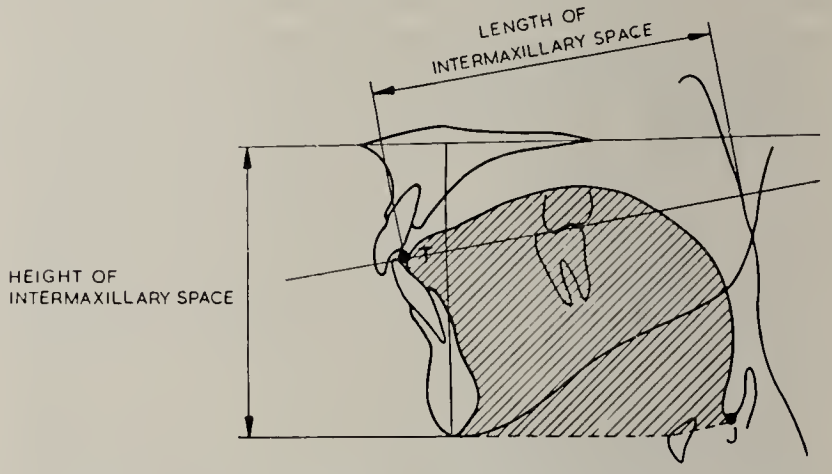

Fig. 3.—Template constructed from the cephalometric tracing showing intermaxillary space and tongue dimensions. Intermaxillary space height is measured as the perpendicular distance from menton to the maxillary plane. Intermaxillary space length at the level of the occlusal plane is measured from the point of intersection with the posterior pharyngeal wall to the point of intersection with the most lingually placed incisor. (Area of tongue is cross-hatched. The perimeter of the hatched area is taken as the circumference of the tongue. Length of tongue is taken from the point J to the tip of the tongue, point T.)

sample. The main differences seemed to be in the relative amounts of horizontal and vertical and also the total movements seen.

A further subjective impression was that variations in the articulatory movements seemed to be related to the size and shape of the intermaxillary space (namely the rigid confines of the tongue) as assessed from the baseline positions with the teeth in occlusion.

Templates were drawn from the original cephalometric tracing of each subject (*Fig.* 3) The structures below and including the nasal floor were traced.

Using a Specto-Analyser analysing cine-projector, the cine-film was projected on the template frame by frame.

Compensation for magnification and slight head movements was made by ensuring that each frame was superimposed on the template using the maxillary outline. This involved frequent adjustments to the position of the projector to maintain the best possible superimposition of the image on the template.

Since the X-ray source to patient distance was 26 in., which is less than the distance used for routine cephalometric radiography, compensation for magnification had to be made.

A sharp pencil was used to make a dot to mark the position of each of the following five points:—

1. Menton (Me).
2. Hyoid (H).
3. Tongue tip (Tt).
4. Highest point on the dorsum of the tongue opposite the flat horizontal part of the hard palate (Td).
5. The most posterior part of the tongue opposite the posterior pharyngeal wall (Tp).

which went beyond the previously recorded vertical and horizontal range of dots already marked on the template had to be added.

An illustration of one such analysis is shown in *Fig.* 4.

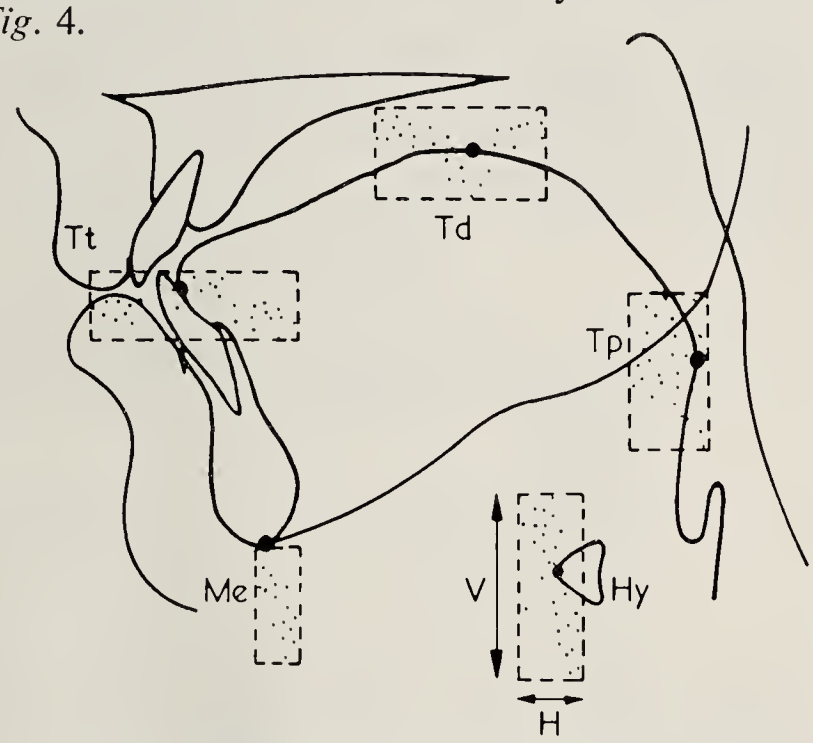

Fig. 4.—Cinedots. The clusters of points represent the movement patterns of menton (Me), hyoid (Hy), tongue tip (Tt), tongue dorsum (Td), and the pharyngeal part of the tongue (Tp). V and H show the vertical and horizontal range of movement of the hyoid.

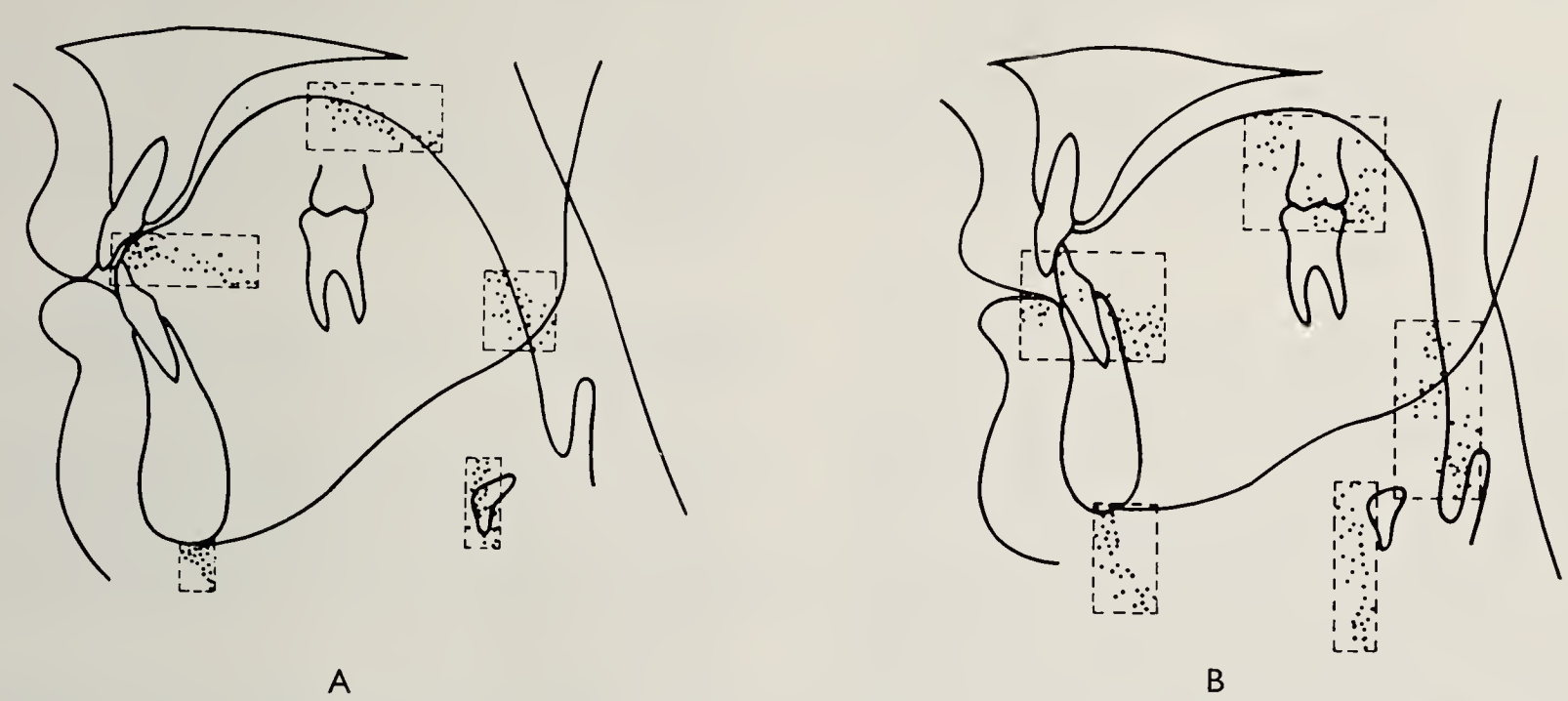

Fig. 5.—Two subjects' cinedots, showing variation in the range of movements of the tongue, mandible, and hyoid in speech. Subject A has a long and high intermaxillary space. Subject B has a short and low intermaxillary space.

As each new frame appeared, the new position assumed by the above 5 points was marked with a dot.

On completion of the entire sequence there were 5 separate clusters of points indicating the total range of movement of each point. Vertical and horizontal measurements of the range of movement of each point could thus be made.

It should be pointed out that not every position of each point had to be marked, since only those

For want of a better name, this method has been called ' cinedots '.

Fig. 5 shows the cinedots obtained from 2 different subjects. Differences in both their morphological and movement characteristics are obvious even without measurement.

The data relating to the vertical, horizontal, horizontal/vertical, and horizontal+vertical range of movements was subjected to several statistical tests.

Reliability of the Method

In this paper only the reliability of the method will be discussed. To establish the reproducibility of the method cinedots, 35 film sequences were analysed in this way. The analysis was repeated by obtaining a second set of cinedots for each sequence. In all, therefore, 70 sets of readings or 35 double determinations for each point's vertical and horizontal movement were obtained.

Table II.—Ranking of Standard Errors in Order of Reliability

Ranking	Standard Error	Point Assessed	
		Vertical	Horizontal
1	0·85	Menton	—
2	1·06	—	Menton
3	1·07	Dorsum	—
4	1·14	Tip	—
5	1·31	—	Hyoid
6	1·42	Hyoid	—
7	1·49	—	Pharyngeal
8	1·60	—	Tip
9	1·71	—	Dorsum
10	2·31	Pharyngeal	—

The standard error for each point's behaviour was calculated using the formula:—

$$\text{standard error}^2 = \frac{d^2}{2(n-1)}$$

where d=the difference between the first and second determination, and n=the number of double determinations.

Table I shows the variation in the standard error of the various points.

It may be seen that the standard errors varied from about 0·9 mm. for the vertical movement of the menton to 2·3 mm. for the vertical movement of the most pharyngeal point of the tongue.

Table I.—Standard Error of Measurements of the Vertical (V) and Horizontal (H) Range of Movements of the 5 Points

	Menton		Hyoid		Tongue					
					Tip		Dorsum		Pharyngeal	
	V	H	V	H	V	H	V	H	V	H
Standard error ±mm.	0·85	1·06	1·42	1·31	1·41	1·60	1·07	1·71	2·31	1·49
2 Standard errors	1·7	2·1	2·8	2·6	2·3	3·2	2·1	3·4	4·6	3·0

The values of two standard errors are also tabulated, since inter-individual differences less than two standard errors may be due to experimental error, rather than to real differences between subjects.

Table II shows the ranking of the standard errors in order of magnitude. This is a measure of the difference in reliability inherent in the study of each point's movement.

The gradation of accuracy with which each point can be determined is related to its ease of visualization. Thus, the calcified structures are more easily localized, whilst parts of the tongue which are most difficult to assess have the highest standard errors.

APPLICATION OF THE METHOD OF CINEDOTS

Having described the method, a simple illustration of just one application will be presented.

Before seeking meaningful relationships between structure and function, the reproducibility of the individual's pattern of behaviour must be verified.

To do this, material obtained from 9 subjects, with 2 cineradiographic recordings, was used to establish the degree of individual consistency in the performance of speech movements. Recordings for these subjects were repeated at intervals ranging from the same day to 6 weeks later.

Differences between the first and second set of values obtained from the cinedot analysis of each point's movement were tabulated in *Table III.*

The value of 2 standard errors for each quantity (obtained from the entire sample) is shown at the foot of each column.

It was found that of a total of 90 measurements of differences in consecutive recordings for 9 subjects, 78 were within 2 standard errors of the

method, 4 were 1 mm. greater than 2 standard errors of the method, and 6 were 2 mm. greater than 2 standard errors of the method. Only 2 were *more* than 2 mm. greater than 2 standard errors of the method.

In other words, over 86 per cent of the horizontal and vertical measurements were reproducible with a degree of consistency within the standard error of the method.

Where discrepancies between the first and second recordings of the speech sequence were greater than 2 standard errors, 10 out of the 12 occurred in the measurements relating to the vertical movement of the oral structures.

This indicates that a very high degree of consistency exists in the individual's pattern of articulatory behaviour.

Furthermore, it is also likely that the intra-individual variation in vertical movements tends to be greater than that for horizontal movements.

Table III.—Consistency of Individuals' Patterns of Articulatory Movements*

Subject No.	Menton		Hyoid		Tongue					
					Tip		Dorsum		Pharyngeal	
	*d*V	*d*H	*d*V	*d*H	*d*V	*d*H	*d*V	*d*H	*d*V	*d*H
1	0·5	0·0	0·5	0·5	1·0	2·5	1·0	4·0	1·0	1·5
2	0·0	1·5	3·0	0·5	3·0	2·5	1·5	0·0	4·0	3·0
3	3·0	2·0	8·5	2·5	1·5	0·0	2·0	2·5	1·5	2·0
4	3·5	0·5	5·0	2·5	4·5	1·0	1·5	2·5	2·5	0·0
5	0·5	1·5	0·5	1·5	1·5	2·5	3·5	2·0	3·0	1·5
6	0·0	1·0	0·5	1·5	0·5	2·5	0·5	0·5	1·5	0·5
7	0·0	0·5	1·0	1·0	2·5	4·5	0·5	1·0	0·0	1·0
8	1·0	0·5	2·5	0·5	1·5	0·5	1·5	2·5	4·5	0·0
9	3·0	0·5	2·0	0·5	1·0	1·5	4·0	2·5	1·0	1·0
2 Standard errors	1·7	2·1	2·8	2·6	2·3	3·2	2·1	3·4	4·6	3·0

*Columns of difference (*d*) refer to the difference between the means of 2 determinations for each of the first and second cineradiographic recording of the 9 subjects. V and H refer to vertical and horizontal movement of the 5 points. All measurements are in millimetres.

SUMMARY

1. A method has been described which can cope with a large volume of data in an efficient and objective manner. The efficiency of the method derives from the need for only one tracing per subject and the ability to utilize a high proportion of the information content of every single frame of film.

2. The method has been shown to be reliable. The standard error of the cinedots technique is of a similar order to those of conventional cephalometric analyses.

3. In this report only one application of the method has been illustrated. By comparing the cinedots obtained from 9 individuals whose records were repeated, a high degree of consistency in the individual's pattern of articulatory movements has been revealed. This suggests two probable facts.

Firstly, that the adaptive behaviour employed by a speaker is characteristic for each individual.

And secondly, that individual variations, both morphological and those concerned with the neuromuscular co-ordination involved in speech, are intimately connected.

CONCLUSIONS

The method described is not considered to be ideal by any means. Further improvements in technique are possible, both in obtaining the films and in the analysis of the material. Higher film speeds, further reduction in radiation exposure, and automatic scanning devices linked directly to a computer are all likely to be available in the near future, thereby further advancing the scope and usefulness of cineradiography in orthodontic research. It is merely hoped that the approach to the previously unsolved problem of a glut of data has been shown to be amenable to our present technical resources. It is also hoped that a fuller account of the study now completed, using this method, will be presented together with the application of a similar approach to prosthetic and oral surgical cases.

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MIDLINE SUPERNUMERARIES AND ERUPTION OF THE MAXILLARY CENTRAL INCISOR

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SUPERNUMERARIES in the premaxilla are said to be the most common cause of failure of eruption of the permanent central incisors. However, only a proportion of cases with supernumeraries in this region have delayed incisor eruption. The incidence of this association varies in recent reports. Gardiner (1961) found that 28 per cent of supernumerary cases at Sheffield had failure of incisor eruption; Day (1964) reporting on 80 consecutive supernumerary cases from the Eastman Dental Hospital, London, recorded an incidence of 39 per cent, whilst Howard (1966) found as many as 60 per cent of supernumerary cases admitted for surgery at King's College Hospital were similarly affected.

Certain types of supernumeraries have been associated with delayed eruption, the tuberculate variety in particular. The root formation of this type and others associated with delayed eruption is often reduced and incomplete. The tuberculate variety also tends to be larger and is situated relatively further from the midline. Though the majority of unerupted supernumeraries are palatally placed they may be found in the line of the arch. It is in this position that they can erupt between the central incisors.

That the supernumerary is responsible for the initial disturbance on the developing dentition is undeniable but it would appear that other factors contribute towards delay in the normal eruptive mechanisms. These could be a generalized or localized crowding of the dental arch, the type of degree of central incisor displacement, and the resulting incisor root formation. It has been suggested that a thickening, of the dental follicle of the central incisor is an important fact (Stoy, 1954), and it is not improbable that the mucous membrane over the erupting incisor might also play a part.

The relative significance of each feature is important in diagnosis and treatment planning especially when predicting the eruption pattern of an affected incisor. Prolonged periods of incisor non-eruption after removal of the supernumerary can give rise to difficulties.

Though the various aspects of the supernumerary in this region have been well recorded (Black, 1909; Stafne, 1932; Flint, 1939; Gardiner, 1961), statistical data are related largely to their incidence in any sample. The relative significance of the various features on the eruption of the supernumerary has not, as far as I am aware, been investigated. In order to investigate more fully these features and their effects on the eruption of the central incisor, a survey was undertaken on cases with supernumeraries of the premaxilla.

METHOD AND MATERIALS

The sample was obtained from the records of 7186 consecutive patients examined in the North East Metropolitan Regional Orthodontic Centre at Whipps Cross Hospital, and in centres at Chelmsford, Colchester, and Southend, during the years 1960–7. One hundred and eighty-eight cases with supernumeraries were found and the records of 165 were suitable for the survey. Their ages ranged from $6\frac{1}{2}$ to 14 years. Details of diagnosis and treatment were recorded using a double determination method. The data was obtained from:—

a. The clinical and surgical notes.

b. Intra-oral, occlusal, and lateral radiographs.

c. Study models.

d. Specimens of supernumeraries.

The supernumerary was related to the maxillary midline suture and details in the premaxillary region were recorded separately for right and left sides in each case. In this way two sets of data were made for each patient and some of the difficulties that occurred in recording bilateral supernumerary cases were overcome. Also where incisors were not associated with a supernumerary recordings enabled comparisons to be made with

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those incisors that were associated with a supernumerary.

The various aspects of diagnosis and treatment were then grouped onto a questionnaire where each group consisted of its variable features. The questionnaire contained 47 groups with 194 possible features. It was completed twice for each case to give 330 sets of data for analysis.

3. *Position of Supernumerary.*—The supernumerary was related to the normal central incisor position and features were recorded in the labiopalatal, mesiodistal, and vertical dimensions. Vertically, the unerupted supernumerary was related to the central incisor position (*Fig.* 1).

4. *Eruption of Central Incisor.*—Recordings were made when the incisors were either erupted

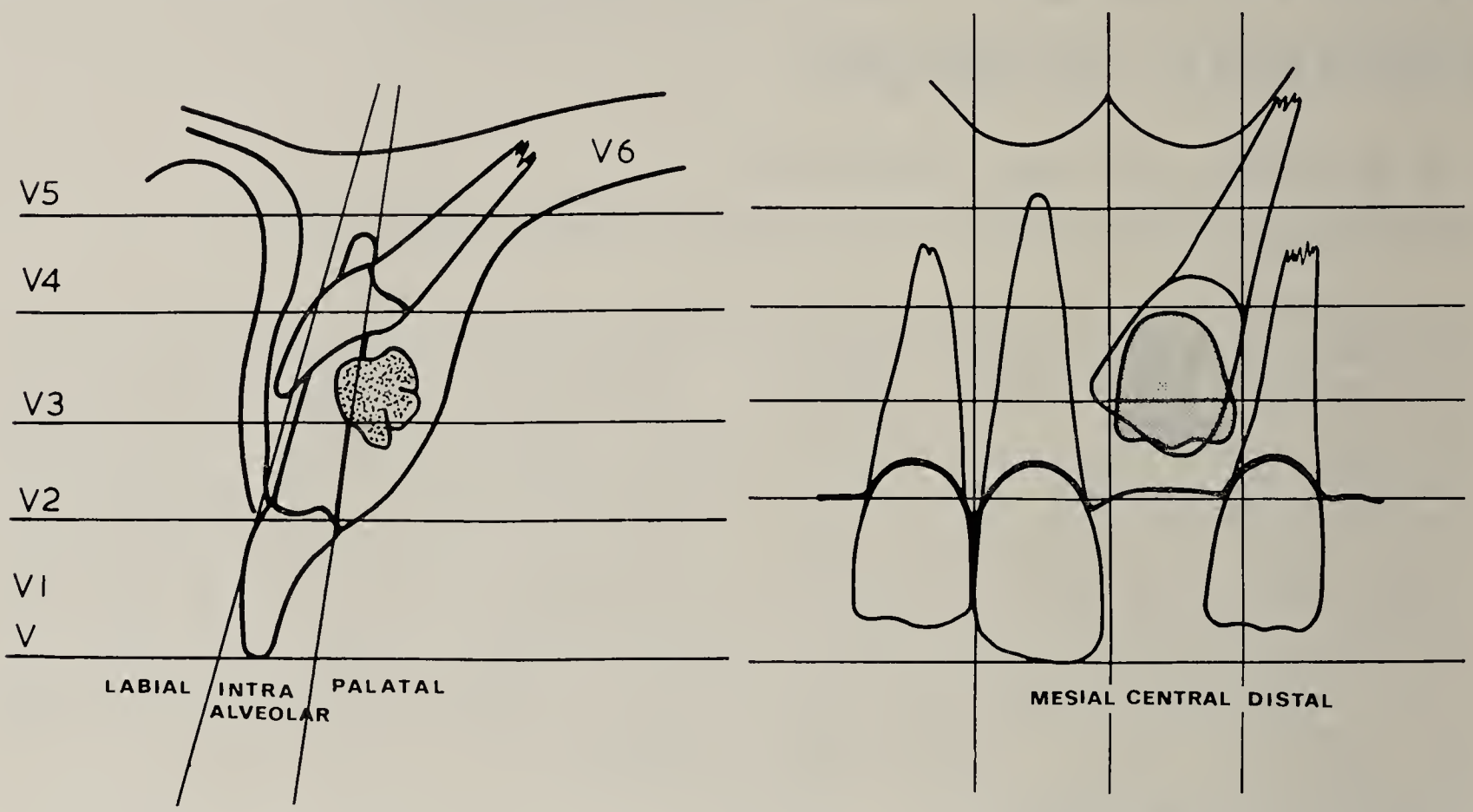

Fig. 1.—Relationships of survey: V, Normal occlusal height; V_1, Partially erupted; V_2, V_3, V_4, each one-third of normal incisor root position; V_5, Apex of incisor; V_6, Palate.

Table I.—Sample of Groups and Features used in the Survey*

Features analysed (with Numerical Coding)	Classifications (with Numerical Coding)
Morphology (18)	Spherical (69), Conical (70), Incisiform (71), Caniniform (72), Tuberculate (73), Odontome (74), Not affected (75)
Relative size (19)	Small (76), Medium (77), Large (78), Not affected (79)
Root formation (21)	Absent (85), Partial (86), Complete (87), Not affected (88)
Direction (22)	Vertical (89), Vertical inverted (90), Horizontal (91), Horizontal inverted (92), Transverse (93), Not affected (94)

*Demonstrating the importance of enclosing negative data to ensure the totals of each group are the same.

The groups and features were coded by a progressive numbering system and the importance of this will be discussed later.

The following is a sample of the groups and features used for this paper:—

1. *General.*—Sex, age, malocclusion, etc.

2. *Features of Supernumerary.*—*Table I* illustrates the features selected for analysis and also the numerical coding used for groups and features.

or unerupted and also whether there were associated supernumeraries.

The data taken from each set of recordings were transferred to punch tape for computer analysis.

By using the progressive numbering system for each feature of the sample rather than just numbering the features in each group separately the computer was able to reject with accuracy incorrectly punched data.

The Elliott 803 computer was programmed to detect:—

1. The total distribution of each feature in the sample.
2. The correlation of features between pairs of selected groups.

The various groups of supernumerary features and supernumerary positions were correlated with the eruption pattern of the central incisor to assess whether any particular features were associated with either eruption or delayed eruption. As many of the features associated with delayed eruption occurred together in particular cases the various groups of supernumerary features and supernumerary positions were then intercorrelated to assess whether any significant pattern existed. An example of a correlation test is shown in *Table II*. The arrangements of the features produced during correlation by the computer were examined visually and unnecessary data deleted. The significance of the distribution was then tested on the basis of the Null Hypothesis using χ^2 and incorporating the correction recommended by Yates (1934) for a binomial distribution.

RESULTS

1. Features of the Survey

Sixty-six per cent of the cases were male and the same percentage distribution was found in the 71 cases with delayed incisor eruption. Of the 165 cases, 46 had bilateral supernumeraries, giving a total of 211 for analysis. Nine cases had an associated cyst and these occurred with the inverted type of supernumerary.

2. Correlation of Supernumerary Features with Central Incisor Eruption

a. Morphology

Conical and incisiform types were associated with eruption, tuberculate and odontome types with delayed eruption. (Conical and caniniform types were amalgamated for this test.)

b. Relative Size

Smaller types associated with eruption, larger types with delayed eruption. The medium types were excluded from the χ^2 test.

c. Root Formation

Complete root formations were associated with eruption, absence and incomplete root formations with delayed eruption.

Table II.—Computer Arrangements and χ^2 Test* Correlation of Supernumerary Root Formation with Central Incisor Eruption

Root Su	Incisor†			
	EA	EU	U	Total
Absent	8	0	45	53
Partial	43	0	38	81
Complete	70	0	7	77
Not affected	0	115	4	119
Absent partial	51	0	83	134
Complete	70	0	7	77
Total	121	0	90	211

2×2 correlation for χ^2 test.
Using Yates:

$$\chi^2 = \frac{(69{\cdot}5 \times 82{\cdot}5 - 7{\cdot}5 \times 51{\cdot}5)^2 211}{121 \times 90 \times 77 \times 134}$$

$$\chi^2 = 53{\cdot}46.$$

*Here significant at the 0·1 per cent level.

†Key: Su, Supernumerary; EA, Erupted Associated Supernumerary; EU, Erupted not Associated Supernumerary; U, Unerupted.

d. Direction

Variations and inversions were associated with eruption, vertical types with delayed eruption.

e. Mesiodistal Position

Mesially placed types were associated with eruption, central and distally placed types with delayed eruption.

Table III.—Distribution produced by χ^2 Test upon Intercorrelation of Various Groups of Supernumerary Features

Morphology	Conical incisiform	Tuberculate odontome
Relative size	Small	Large
Root formation	Complete	Absence incomplete
Direction	Variations and inversions	Vertical
Mesiodistal	Mesial	Central distal
Vertical	V_1, V_4, V_5, V_6	V_2, V_3
Labiopalatal*	Palatal	Palatal

*Not tested

f. Vertical Position

V_1, V_4, V_5, and V_6 positions were associated with eruption, V_2 and V_3 with delayed eruption (*Fig.* 1).

All the above when tested by χ^2 were significant at the 0·1 per cent level.

g. Labiopalatal Position

The majority of supernumeraries were palatal in both eruption and delayed eruption. Variations in other positions were too small to be statistically significant.

The pattern of distribution occurred not only over the whole range of age-groups but also within the earlier (6–10 years) and later (10–14 years) age-groups.

Fig. 2.—Occlusal radiography of 6½-year-old boy. Two supernumeraries with fully formed roots, one erupting, the other inverted and palatally placed to a partially formed central incisor root. Cyst associated with inverted supernumerary. The central incisors erupted before the supernumeraries were removed.

Various other features were also observed, in particular the tendency for some tuberculate types to have defective calcification of the enamel and invaginations which occasionally led to dilated root structures.

DISCUSSION

Many features in this survey confirm the findings of previous reports: for example, the higher incidence of supernumeraries in males agrees with

Fig. 3.—Model of foetal maxilla after 14 weeks of intra-uterine life. Made from microscopic sections, enlarged 10 times, by Rose (1893) and described by Mummery (1893).

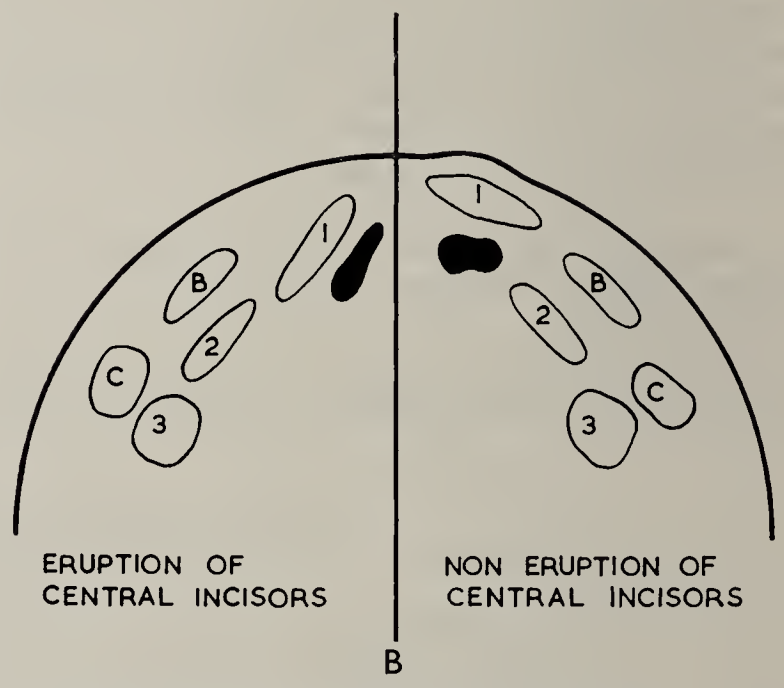

Fig. 4.—Diagrammatic representation of the suggested development of the two types of supernumeraries: A, At 2 years; B, At 7½ years. *Left*, earlier type; *right*, later type.

3. Intercorrelation of various Groups of Supernumerary Features

Each group of supernumerary features was correlated with all other groups of supernumerary features. A typical pattern of distribution was produced regardless of which groups were correlated and these when tested by χ^2 were significant at the 0·1 per cent and 1 per cent levels (*Table III*).

Parry and Iyer (1961) and the 5·4 per cent of cases with cystic supernumeraries is similar to Stafne's findings in 1932.

The 42 per cent of cases with unerupted incisors compares with the 39 per cent found by Day (1964). The higher incidence of this in younger age-groups suggests that some supernumeraries are associated with only a transient delay in incisor eruption.

Though the tuberculate type of morphology was significantly associated with delayed eruption it occurred predominantly in bilateral supernumerary cases. In unilateral cases the conical variety was frequently found.

One of the most striking distributions in relation to incisor eruption was the supernumerary root formation. The reduced and incomplete type associated with delayed eruption could be an indication of the effects of a later developing supernumerary on the incisor eruption. This tendency to later development was noticed by Black in 1909 and has been confirmed by subsequent authorities.

The close association of the supernumerary with the central incisor in delayed eruption and its relatively superficial position vertically, indicates the importance of the site of supernumerary development on incisor eruption.

As many of the above features associated with eruption and delayed eruption occurred together in individual cases, the pattern produced by the intercorrelation of the various groups of supernumerary features supports a theory that two distinct types occur in this region.

Legros and Magitot (1880), in the translation of *The Origin and Formation of the Dental Follicle*, describe the view that supernumeraries arise from the epithelium of the dental lamina and also discuss the view of Kollman, later supported by Magitot, that supernumeraries arise from the proliferating epithelial remnants of the dental lamina. These views were later modified by Black (1909) who suggested two types:—

a. Those arising either directly from the dental lamina or the epithelial connecting chord, gave rise to a supplemental type resembling the dentition from which it arose.

b. From the proliferation of epithelial remnants of the dental tissues giving rise to a rudimentary conical type.

An extension of the dental lamina lingually was suggested by Oehlers (1952) to account for the late-developing lower supernumerary premolar.

If supernumeraries do arise between the dentitions, the ones with complete root structures found palatal and sometimes quite deep to a partially formed central incisor must undergo considerable migration to attain such a position (*Fig*. 2). Also, the incidence of residual dental epithelium in the jaws generally is inconsistent with the high proportion of conical supernumeraries found in this region.

With little chance of obtaining sufficient embryological evidence on supernumerary development any theory concerning their formation remains hypothetical. However, the findings of this survey if present during development could be accounted for as follows:—

The dental lamina is a continuous band across the midline of the upper jaw at 7 weeks of intra-uterine life and would appear to remain so until after the development of the primary incisor tooth germs. At 14 weeks the deeper portions of the lamina become separated in the midline leaving a free mesial margin. This is demonstrated in the models of foetal jaws constructed from microscopic sections by Rose (1893) (*Fig*. 3).

It is suggested that an earlier type of supernumerary could arise in this region often before the permanent central incisor forms. In this way variations of direction could occur by ectopic

Table IV.—Example of Features observed within the Age-groups $6\frac{1}{2}$–14 years

Features	Mesiodont	Palatodont
Morphology	Conical or incisiform	Tuberculate conical or odontome
Relative size	Smaller	Larger
Root formation	Complete	Reduced incomplete
Direction	Variations and invertions	Vertical, occasionally transverse
Mesiodistal	Mesial to central incisor may migrate	Associated with central incisor
Vertical	Variable, may be erupted or deep	Superficial, unerupted
Labiopalatal	Palatal or intra-alveolar, rarely labial	Palatal to central incisor
Eruption of permanent central incisor	Normal or minimal delay	Delay and failure

budding or displacement of the dental lamina. As the dentitions develop downwards, forwards, and mesially, especially in a crowded arch this type of supernumerary could become palatally placed. The migration of an inverted type would contribute towards this (*Fig.* 4).

As supernumeraries often occur in sites where terminal portions of dental lamina exist, this theory of formation might account for the high proportion of supernumeraries seen in this region.

Returning to the development of the central incisor, these arise by a budding of epithelium from the primary predecessors at about 24 weeks of intra-uterine life. It could be that a later supernumerary develops by a similar process from the epithelium of the permanent central incisor palatally. The variations in root formation suggest that development of this type could occur some time after the central incisor tooth germ has developed (*Fig.* 4).

The closer association of this type of supernumerary with the crown of the central incisor would seem to lead to a greater disturbance of its eruption pattern than seen with the earlier type.

The features of these two types can be summarized as shown in *Table IV*. The earlier type is called a ' mesiodont ' and the later type a ' palatodont '.

Acknowledgements

I would like to thank Mr. R. W. Willcocks for the use of his extremely well documented records and his advice and encouragement. I would like also to thank Mr. J. S. Rose and Dr. P. Vig for their advice and help, and Mr. F. Smales for computer programming and statistical advice. I am grateful to the Royal College of Surgeons for the photographs of foetal jaws from the Odontological Museum.

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SOME ASPECTS OF SOLDERING STAINLESS STEEL

A METALLURGICAL INVESTIGATION

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In the early 1930's, when stainless steel began to be used in the construction of orthodontic appliances, the joining together of two orthodontic wires presented some difficulty. Today, even though the soldering of stainless steel enters more into the construction of removable appliances, it can still present difficulties. Although De Coster (1932) of Belgium experimented as early as 1924 in the use of electric welding and later was joined by Friel (1933) and Watkin (1933), nevertheless in the U.S.A., due possibly to the tradition established in the construction of precious-metal orthodontic appliances, it was natural that such pioneers as Brusse and Carman (1934) with Bell (1935), Kadesky (1935), and Walsh (1938) used mostly gold solders for joining stainless steel.

THE NATURE OF STAINLESS STEEL

Stainless steel was discovered by Brierley of Sheffield in 1913 (Monypenny, 1931) and is today the most commonly used metal for all orthodontic appliance construction.

The hardness, tensile strength, and elastic limit are induced in stainless steel by plastic deformation or cold working and its resistance to corrosion is due to its content of chromium and nickel. The most common combination used in dentistry contains 18 per cent chromium and 8 per cent nickel, thus giving rise to the oft-heard name of ' 18/8 stainless steel '; however, despite its popularity, its joining together by soldering still presents difficulties, as it cannot be heated above a certain temperature without losing some of its desirable properties. Heating hard stainless steel up to 450° C. will increase its elastic strength, but heating it above 500° C. will cause annealing and softening, the stainless steel losing its hardness and its tensile strength due to a rearrangement of the crystals previously elongated by cold working. When stress is applied to stainless steel in the annealed state, the regular crystals will easily slip over each other and the material becomes permanently deformed. However, by cold-working the annealed stainless steel, the regular-shaped crystals become elongated and do not easily slip over each other when stress is applied. Yet another complication is that heating stainless steel above 400° C. will also reduce its resistance to corrosion since, due to the formation of chromium carbide at the grain boundaries, the proportion of chromium diminishes in the solid solution adjacent to these boundaries.

FLUX

With regard to fluxes, the earlier workers soon discovered that the borax flux used for soldering gold could not be used when soldering stainless steel. Brusse and Carman (1934) found that a flux consisting of hydrochloric acid, potassium fluoride, boric acid, borax, silica, and sodium carbonate was well-suited to the soldering of stainless steel and this flux was used by most of the early workers. Later, Vosmic and Taylor (1936) tested a number of fluxes used for soldering stainless steel and came to the conclusion that the most effective fluxes were those consisting of 1 part boric acid and 2 parts potassium fluoride moistened with a liquid of 1 part hydrochloric acid and 5–6 parts water. The Commonwealth Bureau of Dental Standards (1960) recommended that the flux to be used when soldering stainless steel should consist of 3 parts by weight of boric acid.

SOLDER

The early workers, such as Brusse and Carman (1934), Bell (1935), Kadesky (1935), and Walsh (1938), used mostly gold solder with a low copper content and a low fusing point. Vosmic and Taylor (1936) tested the strength of soldered

Presented at the meeting held in Manchester on 18 March, 1969.

stainless-steel joints made with various solders and they found that the strongest were made with a solder having the following composition:—

Silver	42 per cent
Copper	31 per cent
Zinc	20 per cent
Cadmium	7 per cent

Such a solder gave joint strengths of between 77,500 lb. per sq. in. and 118,300 lb. per sq. in. The Australian Standards Association (1964) specified that dental silver solders should contain:—

Silver	40–89 per cent
Copper	10–35 per cent
Zinc	10–30 per cent
Cadmium	0–20 per cent
Nickel	0– 3 per cent
Other elements	0– 0·5 per cent

Skinner and Phillips (1960) and Anderson (1961) mentioned a number of silver solders for soldering stainless steel, all within the above specification of the Australian Standards Association.

They also claim that since gold solders must be of 10 carat quality to ensure a low enough melting point, silver solders are better suited for the joining of stainless steels.

HEATING

Just as lighting is to photography, so heat control is to successful soldering. The early workers used a gas–air flame for heating when soldering stainless steel and this method is still favoured by many operators, such as Skinner and Phillips (1960), Wilkinson (1960), and Adams (1964), but the Commonwealth Bureau of Dental Standards (1960) and also Dickson (1964) recommended a plain gas flame without air for this heating, and more recently, portable butane gas burners have become available. Various other heating methods have been described to limit the heating of especially the stainless-steel wire during soldering operations. Klein (1946) and later Perlow (1954) using a gas–air flame, both described a method of first flowing the solder on to the attachment and then putting this with the solder, still molten, on to the wire arch, which would then only require a minimum of heating. Richman (1956) using a gas–air flame, described a soldering method whereby the solder was applied to the soldering point by way of an intermediary wire, rather in the manner of the old-fashioned ' soldering iron '. Gaston (1951) and Parker (1960) both described an electric carbon-tip soldering technique which takes advantage of the fact that the passage of an electric current through a carbon point creates extremely high temperatures at the tip of the carbon, thus concentrating the heat where the carbon point touches the stainless steel and minimizing the area to be heated. In another method Leighton (1952) and Wallis (1953) heated a section of a stainless-steel arch by passing an electric current through the actual wire until the solder melted, then inserted the spring, etc., into the molten solder so that the heating of the latter was reduced to a minimum.

NATURE OF THE JOINT

The nature of the soldered stainless-steel joints has also been studied by Vosmic and Taylor (1936), Henns (1953), Richman (1956), Bien and Ayers (1959), and Kohl (1964) but only Henns claims proof of inter-alloying between the silver solder and the stainless-steel wire. Townend (1946), Gaston (1951), the Commonwealth Bureau of Dental Standards (1960), Adams (1964), and Dickson (1964) all maintain that the soldered joint between silver solder and stainless steel is purely mechanical.

PROBLEMS INVESTIGATED

After studying the above literature and from practical experience it was felt that certain aspects of soldering stainless-steel wire still needed further elucidation, for instance:—

1. Which soldering method gives the strongest joints?
2. Which soldering method causes the least softening of the stainless-steel wire around the joint?
3. To what extent is the wire softened as a result of the heat applied during soldering?
4. What is the effect on the stainless-steel joints of the distance between the two parts to be soldered?
5. Is there any evidence of inter-alloying between the silver solder and the stainless steel?
6. What is the extent of crevice corrosion at the edge of the soldered joints?

SOLDERING EXPERIMENTS PERFORMED

In order to investigate these questions, butt-ended soldered joints were made in a special jig (*Fig.* 1), and experiments were performed by two operators, working independently, upon methods of applying heat to the soldered joint such as:—

a. Directly from a gas–air flame.
b. Directly from a plain gas flame.
c. Indirectly through a gas–air heated intermediary wire or ' soldering iron '.
d. Indirectly through an electrically heated intermediary wire or ' soldering iron '.
e. Indirectly through an electrically heated carbon tip.

Also varying gaps were left between the ends of the wires to be soldered and yet a further series of soldered joints was made with one of the wires being heated twice to soldering temperature.

MATERIALS USED

The stainless-steel wire used in these tests was the ordinary 18/8 type commonly used in the construction of orthodontic appliances. It was 1 mm. in diameter, produced in straight 30 cm. lengths and was made to a standard specification (EN 58A). A typical analysis of this product as given by the manufacturer is:—

Iron	71·085–72·365 per cent
Chromium	18·1–18·4 per cent
Nickel	8·4–8·9 per cent
Manganese	0·64–0·96 per cent
Silica	0·41–0·52 per cent
Carbon	0·06–0·10 per cent
Phosphorus	0·019–0·02 per cent
Sulphur	0·006–0·015 per cent

This wire was supplied in the 'hard' state through cold drawing and its tensile strength was between 246,400 lb. per sq. in. and 268,800 lb. per sq. in. It was cut into 10 cm. lengths and the ends were ground flat at right angles to the long axis of the wire and then polished with a rubber wheel. Extreme care was taken to ensure that these ends were flat and smooth. A special jig was constructed to ensure coincidence of the long axes of the two pieces of wire to be soldered when making the experimental butt-ended joints (*Fig.* 1).

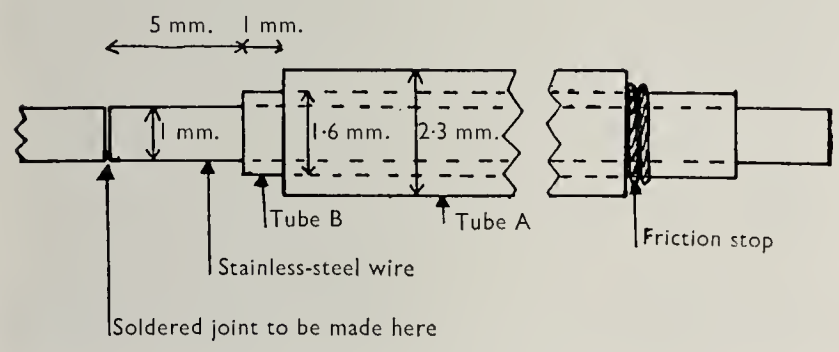


Fig. 1.—Construction of jig.

This jig consisted of a stainless-steel tube with an external diameter of 2·3 mm. and internal diameter 1·6 mm. soldered across a horse-shoe shaped brass plate 2 mm. thick. Another stainless-steel tube 1·6 mm. external diameter and 1 mm. internal diameter was fitted inside the previous tube and a 12-mm. piece taken out of the middle portion of these tubes (*Fig.* 2). The free-sliding tubes were fitted with stops and they were so trimmed that a 10-mm. gap would be left in the middle when they were pushed into the fixed tubes. There was however no 'play' between either the wire specimens and the free sliding tubes or between the latter and the fixed tubes. Because of excess solder increasing the diameter of the joint, the free-sliding tubes were removed first and then the soldered wires. All the excess solder was removed by grinding with a dental stone (*Fig.* 3) so that the layer of solder between the prepared ends of the wire was the same diameter as the wires themselves.

In all these experiments the same solder and flux were used throughout. The solder went under the trade name of Easy-flo No. 3 and the manufacturer gave the following information about its composition:—

Silver	50 per cent
Copper	15·5 per cent
Cadmium	16 per cent
Zinc	15·5 per cent
Nickel	3 per cent

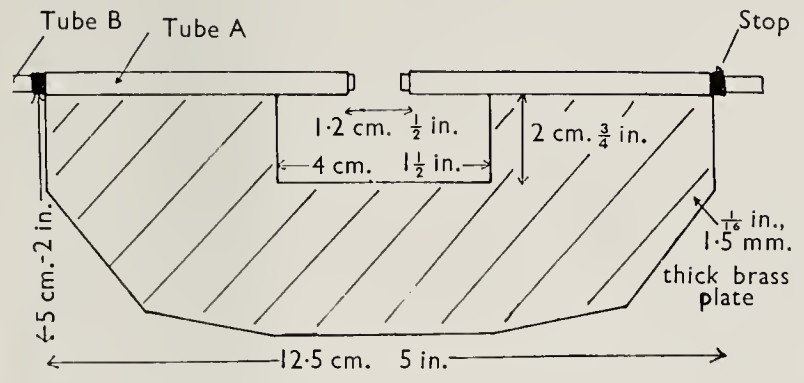
The tolerances are ±0·5 per cent except for nickel which is ±0·3 per cent.

This solder was supplied in wire form 0·45 mm. in diameter and its melting range was 634–653° C.

The flux used in this series of experiments has the trade name of Easy-flo Stainless-steel Grade but its composition was more difficult to ascertain; the only information given by the manufacturer was that it contained 'borates, fluorborates, and complex compounds of potassium, boron, and fluorine' but an analysis of the flux gave the following results:—

Potassium	26 per cent by weight
Boron	8·5 per cent by weight
Fluorine	16 per cent by weight
Water up to	100 per cent

It was supplied in powder form and before use was mixed with water in accordance with the manufacturer's instructions.



Tube A soldered to brass plate
Tube B free standing

Fig. 2.—Detail of jig.

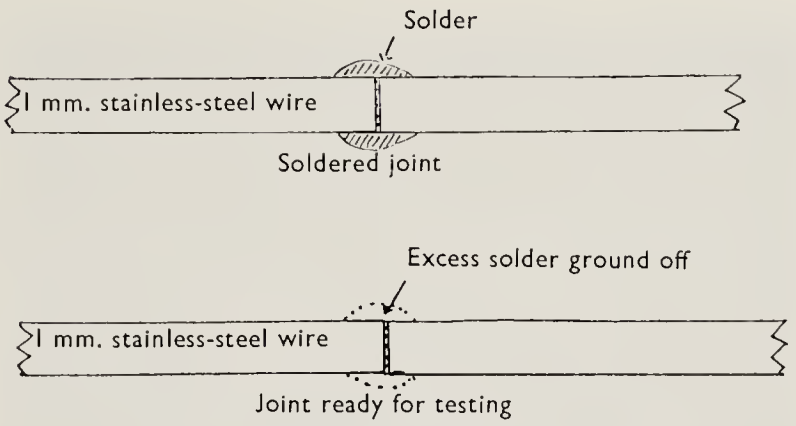


Fig. 3.—Removal of excess solder.

SOLDERING METHODS INVESTIGATED

Five soldering methods were investigated.

A. Soldering with Heat applied directly from a Gas–air Flame

The flame from a Gruenberg gas–air burner was adjusted to give a $\frac{1}{2}$-in. flame and the air-supply adjusted until it was just below ' hissing point ' to form a small cone-shaped flame (*Fig.* 4). The gas was the ordinary coal gas from the municipal supply and the air came from a central

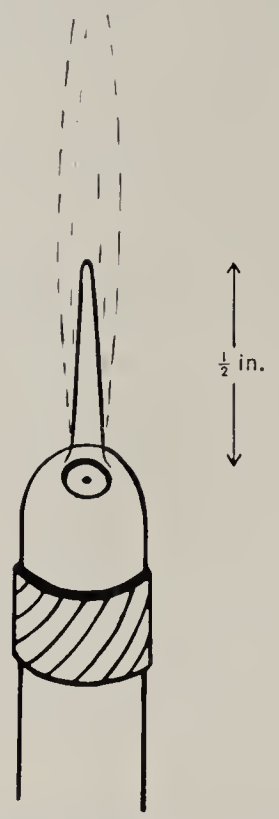


Fig. 4.—Gruenberg gas–air burner with flame.

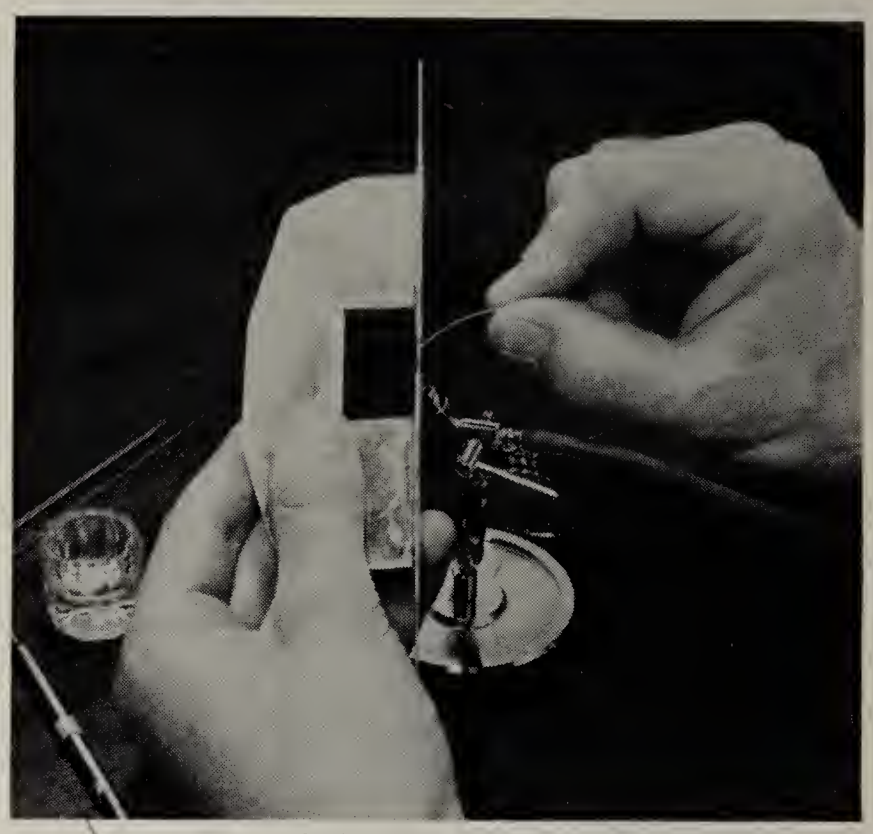


Fig. 5.—Soldering over Gruenberg burner.

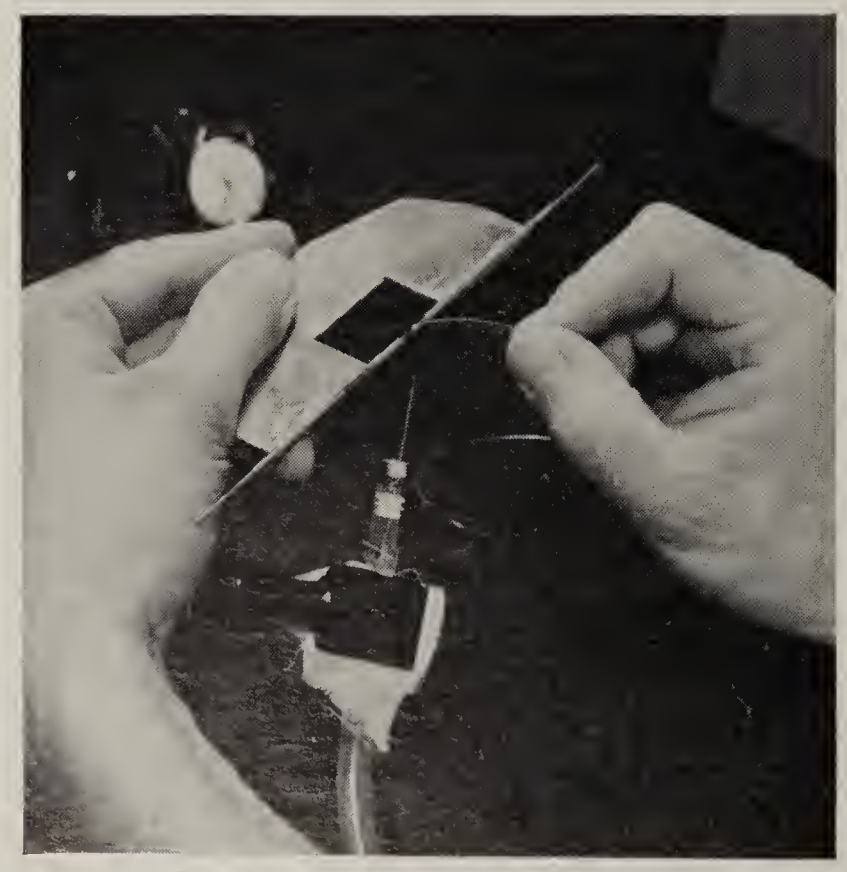


Fig. 6.—Plain gas soldering torch.

compressor. To be able to see the flame better, all soldering operations took place against a black background. The wires were assembled in a specially made jig, the ends of the wire wiped with alcohol then pushed together and the flux applied. The wire ends were then put into the top part of the flame and as the flux melted the solder was applied (*Fig.* 5). The stainless-steel wires were removed from the flame just as soon as the solder had flowed freely. The soldering times were measured from when the wires were put into the flame to the point when the soldering was completed. As a check upon any individual variations, two operators (A and B) took part and each did a soldered joint independently. Operator A also did a further 10 assorted joints with a 0·15-mm. gap between the two wires measured by passing a piece of 0·15-mm. stainless-steel tape between the wires when in the jig.

B. Soldering with Heat applied directly from a Plain Gas Flame

A soldering torch was made after the specification of the Commonwealth Bureau of Dental Standards (1960) as shown in *Fig.* 6; an 18 gauge intramuscular needle (internal diameter 0·8 mm.) with its point ground down was mounted in an empty local anaesthetic cartridge with a rubber tube connected to the coal-gas supply. The flame was adjusted to approximately $\frac{1}{2}$ in. in length and the same procedure used as in Method A.

C. Soldering with Heat applied through an Intermediary Wire (or ' Soldering Iron ') heated by Gas–air Flame

A 0·5-mm. diameter brass wire was extruded from a short length of stainless-steel tubing as shown in *Fig.* 7. Flux was applied to the end of the brass wire which was then held in the gas–air burner flame (as in Method A) and solder applied to the end of the brass wire. The stainless-steel wires were assembled in the jig in the usual way,

the flux applied, and the wires held in the flame until the flux melted. The wires were then removed from the central part of the flame but kept near enough to it to keep the flux molten. The

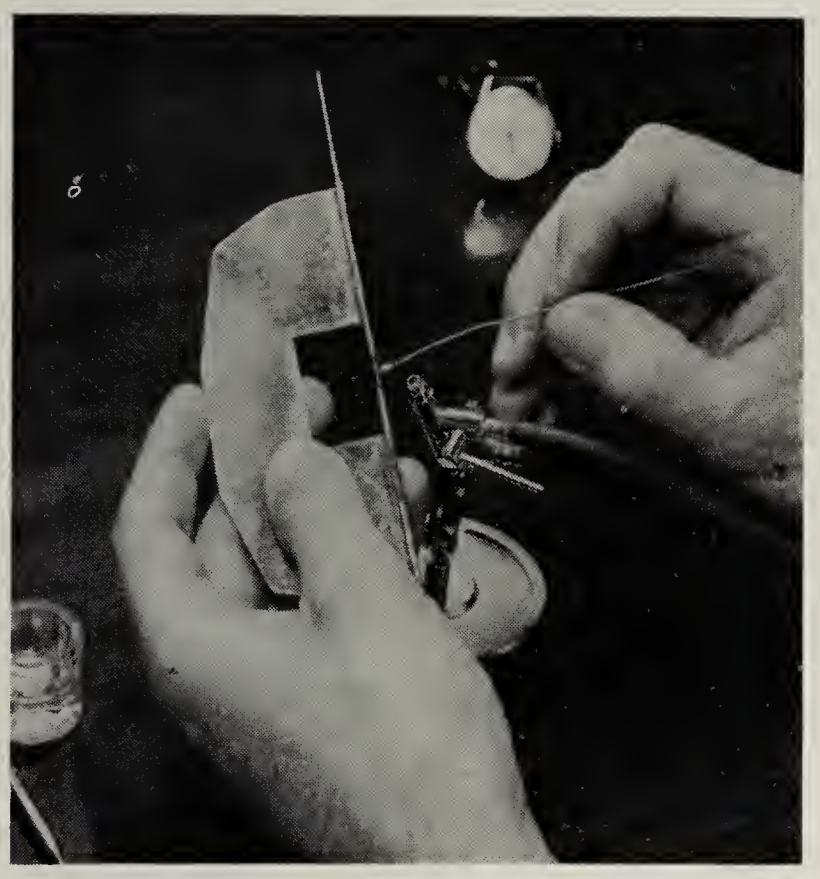


Fig. 7.—Brass wire ' soldering iron '.

brass wire with the solder in place was then replaced in the flame until the soldering was complete; the timing of this method did not include the time taken to prepare the solder on the brass wire.

D. Soldering with Heat applied through an Intermediary Wire (or ' Soldering Iron ') heated Electrically

In this method the ' soldering iron ' used was that connected to a Rocky Mountain 506A welder (*Fig.* 8) and was adjusted until it glowed with a cherry-red heat. The area of the joint was then applied directly to this hot ' soldering iron ' after fluxing and the solder applied until it flowed freely. In this method the soldering time was measured from the point when the wires were in contact with the hot ' soldering iron ' to the point when the soldering was completed.

E. Soldering with Heat applied through a Carbon-tip Electrode

Again use was made of a Rocky Mountain 506A welder. The stainless-steel wires were assembled in the jig but the flux applied had been mixed to a thinner consistency than usual as this improved the conduction of the electric current. A small piece of solder was pressed flat and put between the stainless-steel wires in the jig and continuous pressure applied to approximate the wire ends. The crocodile clip electrode was connected to one of the wires to be soldered but as close to the joint as possible (*Fig.* 9); the electric current was then switched on and the carbon-tip electrode touched on to the other wire as close to the joint as possible until the solder flowed

Fig. 8.—Electrically heated soldering iron.

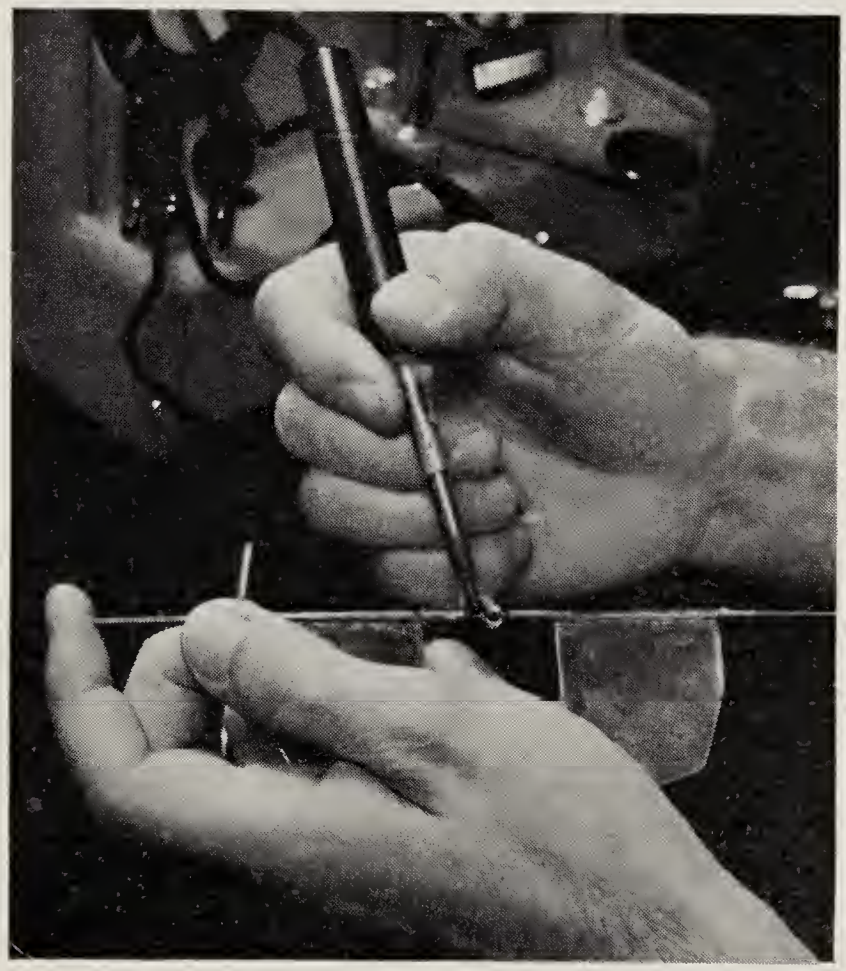


Fig. 9.—Soldering by carbon-tip electrode.

when the wires were moved together under pressure. The heating time was very short by this method, being in the region of half a second.

F. Free-hand Soldering using a Gas–air Flame

As a control, operators A and B each did a series of 5 free-hand butt-ended soldered joints without the jig being used, and as a further check one of the wires to be joined was heated twice.

TESTS APPLIED TO JOINTS

Experimental Investigation of Crevice Corrosion

Four single wires had solder applied by methods A, B, and D and half these specimens (i.e., 2 from each soldering method) had the edge

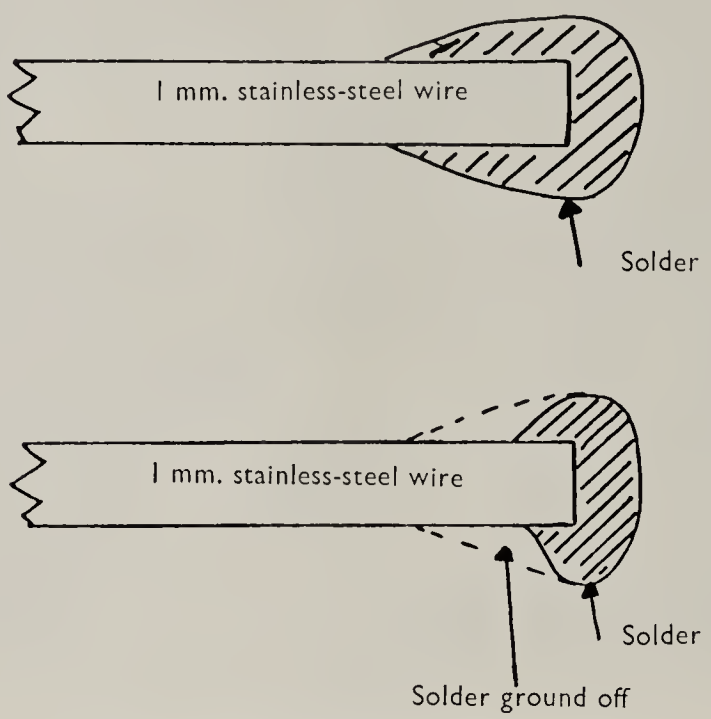


Fig. 10.—Polishing the soldered joint.

Fig. 12.—Low-power examination of fractured joint. (×15.)

of the solder ground off with a dental stone and polished with a rubber wheel (*Fig.* 10). The other specimens were left untouched after the flux was removed. All the specimens were then put into water for 5 weeks and this was agitated twice a day. The appearance of the specimens after 5 weeks in water can be seen in *Fig.* 11.

Tensile Strength of Soldered Joints

All the above butt-ended stainless-steel joints were mounted in a Hounsfield tensometer and the load recorded that was needed to pull the wire apart when a 250-lb. (115-kg.) beam was used. The resulting load was then converted to lb. per sq. in. and kg. per sq. cm.

Low-power Examination of the Fractured Joint Surfaces

The 2 wires from each fractured joint were examined end-on through a microscope at a low-power magnification using reflected light (*Fig.* 12), thus enabling the nature of the fracture and its situation to be observed.

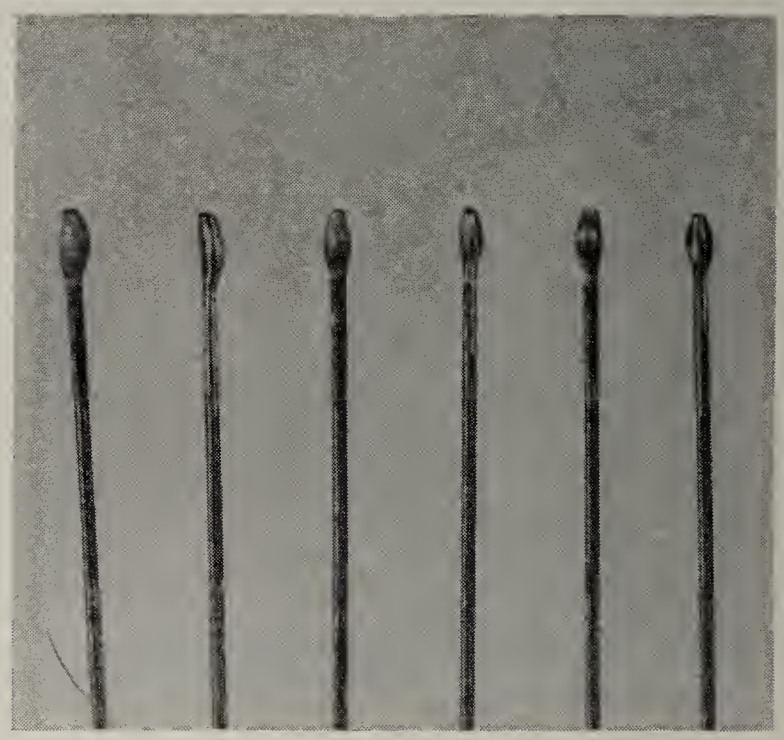


Fig. 11.—Crevice corrosion test. The first pair on the left, polished and unpolished, were soldered by a pure gas flame, the second pair by a gas–air flame, and the third pair by an electric ' soldering iron '.

Mounting the Wire Specimens

To enable higher power metallographic examination and microhardness tests to be performed, about 2 cm. of the stainless-steel wire adjoining the soldered joint were placed in a cylinder and embedded in a thermoplastic resin. The resulting cylindrical blocks could then be sectioned or ground in any desired direction and then polished and etched before examination.

Microhardness Testing

The mounted specimens were placed under a Leitz Durimet miniload hardness tester (*Fig.* 13) using a load of 100 g. The resulting indentation made by the diamond was measured diagonally in thousandths of a millimetre and the Vickers hardness number found from a conversion table using the following formula:

$$HV = \frac{1854{\cdot}2 \times P}{d^2}$$

where HV was the Vickers hardness in kg. per sq. cm., P the load in g. and d is the diagonal of the diamond indentation.

The first reading was taken 0·1 mm. from the soldered end of the stainless-steel wire. A second set of 2 or 3 readings were 0·4 mm. from the soldered end and further readings at 0·3 mm. intervals along the wire until the hardness had returned to what was normal for that wire (i.e., 540–570 VHN).

Metallographic Examination

So that a cross-section of the solder/stainless-steel interface could be examined more closely, the prepared specimens were placed under a microscope giving a magnification of 600–1200. Due to the difference in hardness of the stainless steel, the solder, and the mounting medium, it was inevitable that a bevel resulted in the edge of the stainless steel when the specimens were polished, so that, under such a high magnification, the whole area could not be in focus at the same time. Accordingly, the specimens to be photographed were ground obliquely to the long axis of the wire and specially fine polishing paste used.

RESULTS

The results of the tests could be summarized in *Table I.* As described earlier the soldering time was taken from when the source of heating was applied to the wire to when the solder ran freely and it will be seen that this time varied not only with the method used but also with the operator.

The third column indicates the load used in the Hounsfield tensometer when the joint parted.

When the fractured surfaces of the joints were examined under a magnification of 30 it was seen (*Fig.* 14) that the fracture line occurred across the body of the solder leaving a thin film of solder over the ends of both the stainless-steel wires. Distributed over the full area of the fractured

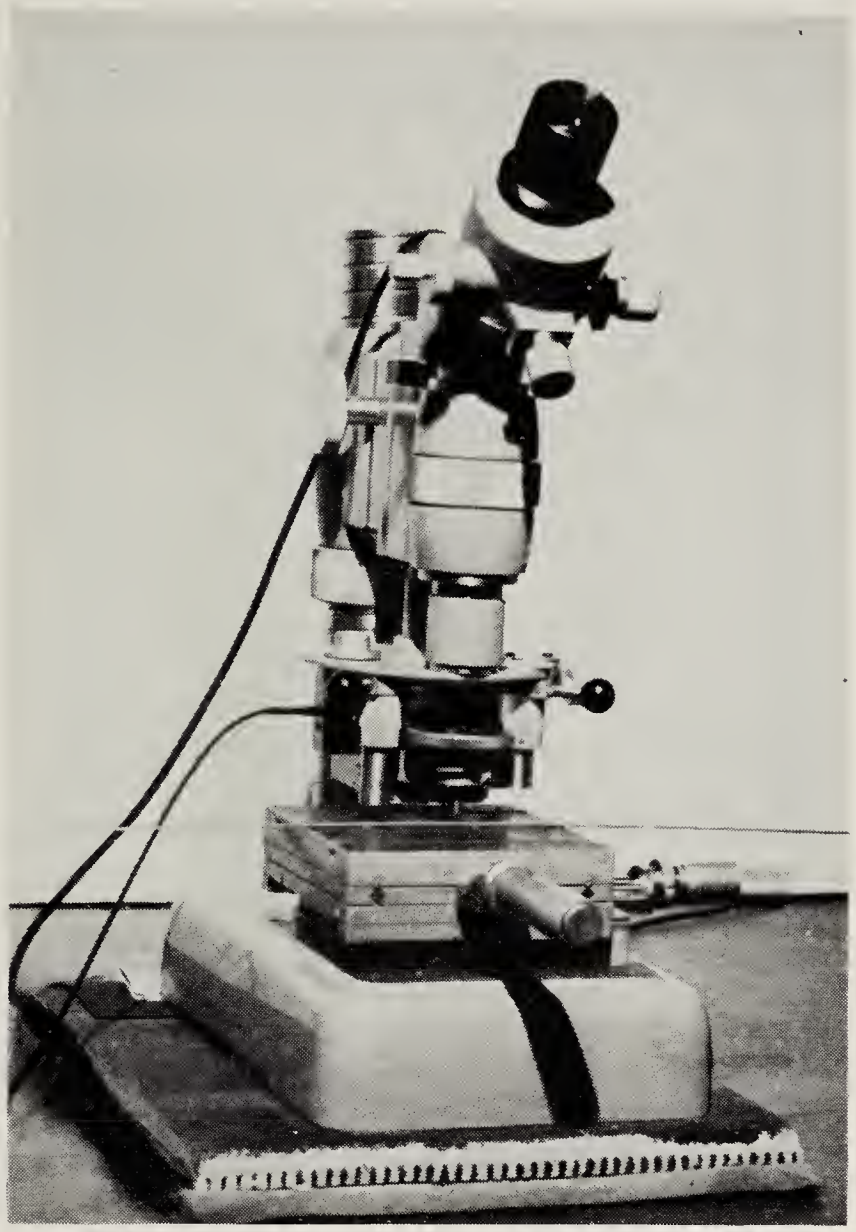


Fig. 13.—Leitz Durimet miniload hardness tester.

Table I.—Results of Tests upon Various Soldered Joints

Soldering Method	Mean Soldering Time (sec.)	Mean Breaking-point of Joint (lb.)	Mean Porosity* (per cent)	Softening of Wire† (mm.)
A. Gas–air flame				
Operator A	9·16	78	12	
Operator B	8·3	74	16	1
With 0·15 mm. gap	8·9	76	5	
B. Plain gas flame				
Operator A	23·0	87	10	1·9
Operator B	11·9	48	7	
C. ' Soldering iron ' heated by gas–air flame	13·7	101	8	1
D. ' Soldering iron ' heated electrically	17·8	80	7	2
E. Carbon-tip electrode	0·5	58	10	1·7

* Total area of voids as percentage of total fractured area.
† Measured as distance in millimetres of VHN 500 from the joint.

surface, ' voids ' could be seen and at this magnification appeared as dark hollows against the rougher surface of the fractured solder. As the frequency of these voids or the porosity varied between the different joints and in order to form some comparison, the total area of those voids was expressed as a percentage of the whole

Fig. 14.—The surface of one side of a fractured joint.

fractured area of the end of the wire: thus the 16 per cent of one joint in the tables would indicate that its porosity was greater than say 8 per cent in another joint.

It was found that the porosity of the joint was inversely proportional to the amount of flux used, i.e., the more the flux the less the porosity, but more investigation of this point is required.

Relationship of the Tests

At least 10 specimens were prepared of each soldering method and *Table II* gives an example of the results obtained with at least one method. A mean value was taken of the 10 specimens in each of the 5 methods investigated and these were compared (*Table III*).

In the gas–air flame soldering method it will be noticed that there is a difference between operator A and operator B as one would expect. It was found for instance that one operator held the joint above the outer cone of the gas–air flame whilst the other operator held the joint in the hottest part of the flame, i.e., immediately above the inner cone, and this has affected the soldering time. Leaving a gap between the ends of the wire to be soldered did not affect the strength of the joint as much as one would expect but it did reduce the porosity.

The difference between the two operators is even more marked when a plain gas flame was used to supply heat to the soldered joint. It was found that operator A had been using the ' cooler' part of the plain gas flame when soldering and this would account for the longer soldering time. It was also found that the fluxing technique in this method varied between the two operators and this could again account for the rather marked difference in their results.

The details of the results obtained with soldering Method C (' soldering iron ' heated by gas–air flame) appear in *Table II*. Again it can be seen that there appears to be a relationship between the strength of the joint and the area of voids in the solder, i.e. ,the strongest joins had a porosity of 5 per cent and the weakest joint 12 per cent and 16 per cent respectively. The joint could also be divided into the first 5 which had a normal amount of flux used and the last 5 which had a minimum of flux. It is noticed that this has had an effect on the porosity of the joint and is measured by the area of the voids compared with total area of the fractured joint surface.

Table II.—Results of Soldering by Method C

Specimen No.	Soldering Time (sec.)	Comments	Breaking-point of Joint			Porosity* (per cent)
			lb.	lb. per sq. in.	kg. per sq. cm.	
1	17	Nil	143	117,500	8230	5
2	7	In the flame	118	97,000	6790	7
3	25	Not in flame	68	55,900	3910	16
4	25	Not in flame	117	96,200	6730	2
5	27	Nil	123	101,100	7080	5
6	8	Minimum of flux	101	83,000	5810	7
7	6	Minimum of flux	68	55,900	3910	12
8	8	Minimum of flux	89	73,300	5120	10
9	7	Minimum of flux	88	72,300	5060	10
10	7	Minimum of flux	92	75,600	5292	10
Mean	13·7		101	82,800	5800	8

* Total area of voids as percentage of total fractured area.

In soldering Method D (electric ' soldering iron ') the results were very similar to those obtained by Method A (gas–air flame) even when a 0·15-mm. gap had been purposely left between the ends of the wire. On investigation it was found that when this type of ' soldering iron ' was pressed against the wire ends it could cause them to separate slightly.

When a carbon point was used to provide the heat for soldering, the soldering time was the shortest of any method but the joints produced were amongst the weakest. Microscopic examination of the joint showed that there were large areas of fracture between the solder and the stainless-steel interface. One therefore presumes that possibly the heating by this method was not evenly distributed across the area of the joint.

As a control some wires were soldered ' free-hand '. Microscopic examination of these showed that the ends of the wire did not coincide as exactly as those joints made in the jig.

Microhardness Tests

The hardness of stainless-steel wire is of practical significance for Wilkinson (1960) showed that its hardness is directly proportional to its tensile strength. As mentioned earlier, the hardness of the wire in the region of a soldered joint was ascertained by using a Leitz Durimet miniload hardness tester working on the principle of using a load of only 100 g. which, through a small diamond point, left a tiny indentation in the wire and this was measured by viewing through a microscope. It was thus possible to determine the hardness of the wire right up to the soldered joint. Although 3 tests were made in each section of the wire it was difficult to get these close enough to overcome the minor local differences due to unequal heating of the wire, etc. The results were expressed as a Vickers hardness number and it was found that the unheated wire had a Vickers hardness number of approximately 570. If, therefore, an arbitrary hardness such as 500 were selected, the linear distance of this from the joint could be measured and compared (*Table III*).

Table III.—Softening of Wire after Soldering by Various Methods

Method	*Softening**
A. Gas–air flame	1
B. Plain gas flame	1·9
C. ' Soldering iron ' heated by gas–air flame	1
D. ' Soldering iron ' heated electrically	2
E. Carbon-tip electrode	1·7

* Measured as distance in millimetres of VHN 500 from the joint.

In the case of the plain gas flame (Method B) the softening of the wire could possibly be explained by this being a ' cooler ' flame requiring a longer soldering time. In the case of Method D (' soldering iron ' heated electrically) that part of the ' soldering iron ' applied to the wires was rather wide in extent and therefore heated a greater length of wire than other methods. In the case of soldering by Method E the complication was that it was necessary to place a crocodile-like clip on one wire in order to conduct the electric current from the carbon tip applied to the other wire. The majority of the heat therefore was supplied by the side in contact with the carbon electrode and although the maximum heat was achieved exceedingly quickly by that method, it obviously had very little time to be distributed evenly.

Metallographic Examination

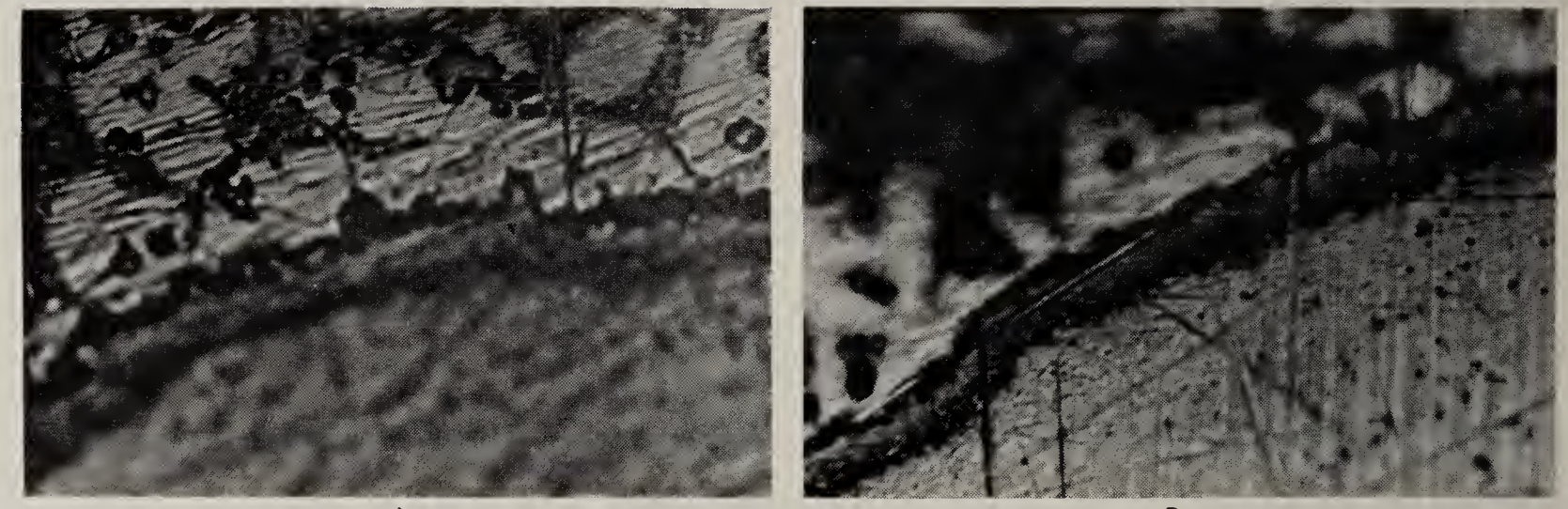
The metallographic examination of the soldered joints was done under a specially designed microscope giving a magnification about 800 to examine the solder/stainless-steel interface in the section.

The specimens that had been soldered ' free-hand ' were used as a control and their appearance can be seen in *Fig.* 15. On the left of the picture is the stainless-steel wire that had been heated once only, in the middle is the solder, and on the right-hand side of the picture the stainless-steel wire that had been heated twice. This picture was taken at a magnification of 400 times when there appears to be a sharp line between the solder and the stainless steel appearing very slightly thicker on the right side, i.e., that side which had been heated twice. In order to examine this intermediary zone more closely the specimens were specially mounted so that this zone could be ground obliquely and its area therefore increased. *Fig.* 16 shows the appearance of such a specially mounted specimen magnified 640 times, the stainless steel appearing in the bottom of the picture and the solder towards the top. A yet higher magnification of 660 times of this area appears also in *Fig.* 17 being focused both on the solder/intermediary-zone interface (*Fig.* 17A) and on the stainless-steel/intermediary-zone interface (*Fig.* 17B).

Microscopic examination of the various specimens soldered by a gas–air flame, by a plain gas flame, by a ' soldering iron ' heated by gas–air flame, and by a ' soldering iron ' heated electrically all showed these 3 layers—stainless steel, intermediary zone, and solder. In the case, though, of those specimens soldered by the carbon-tip electrode, the intermediary zone appeared to be thinner than that of other soldering methods and the solder appeared to have broken away from the stainless-steel surface on a few of the specimens; one possible explanation of this is that the speed with which the soldering temperature was reached by this method resulted in an unequal distribution of heat along the stainless-steel surface.

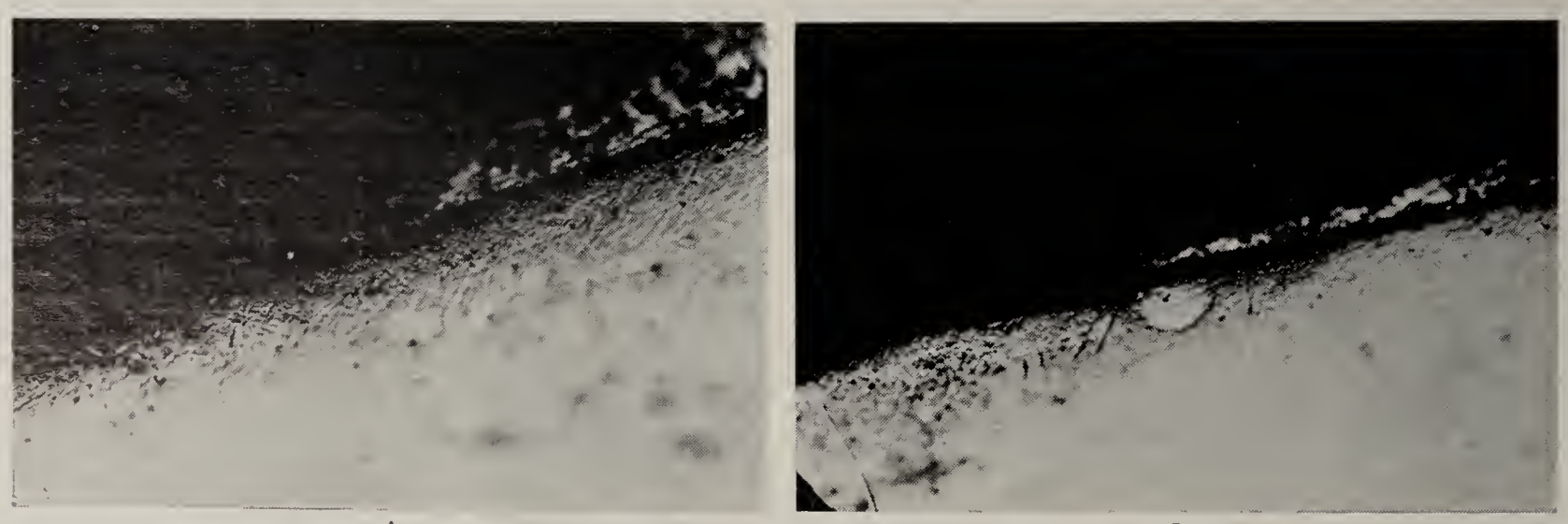
Fig. 15.—Cross-section of typical soldered joint. (×400.)

Fig. 16.—Specially mounted specimen. (×640.)



A B

Fig. 17.—Same specimen as in *Fig.* 16. A, Focused on the solder/intermediary-zone region; B, Focused on the stainless-steel/intermediary-zone region. (×660.)



A B

Fig. 18.—A, The polished soldered wire section. Here the solder is the speckled wedge-shaped area. B, The unpolished soldered wire showing above the mounting medium, then the solder appearing speckled and below the stainless steel. Corrosion is shown as the clearer area at the solder/stainless-steel junction.

Crevice Corrosion Examination

Fig. 11 shows the specimens that were examined for crevice corrosion and it was seen that there was no corrosion of the stainless-steel wire adjoining the solder on the specimens that had been polished (i.e., those on the right of each pair) whilst the unpolished specimens (i.e., those on the left of each pair) showed some evidence of corrosion next to the solder.

The metallographic appearance of these specimens are seen in *Fig.* 18, the polished specimen being shown in *Fig.* 18A. In each illustration the solder is the spotted, wedge-shaped area above, whilst the clearer area below is the stainless-steel, and the black layer in between is the intermediary zone. These specimens were the ones soldered with the plain gas flame but specimens produced by the other soldering methods had a similar appearance. The corrosion is seen as a small circular area in the lower picture. Possibly greater evidence of crevice corrosion might have been apparent if a stronger electrolyte than plain water had been used.

CONCLUSIONS

As a result of the experiments and tests carried out in this investigation the following information was obtained:—

1. The strongest soldered butt-ended stainless-steel joints were made with soldering by Method C (soldering with heat applied through a ' soldering iron ' heated by gas–air flame) then, in descending order of strength of the resulting joints, followed soldering by Method B (plain gas flame), Method D ('soldering iron' heated electrically), and Method A (gas–air flame); the soldering Method E (carbon-tip electrode) produced the weakest joints in this series. This latter may have resulted from poor electrical and heat conduction in the joint itself.

2. The least softening of the stainless-steel wires was produced by soldering Method C (' soldering iron ' heated by gas–air flame). In soldering Method A (gas–air flame) there was also little softening of the adjoining wire but there was more softening in soldering Method B where a plain gas flame was used, possibly because the latter, being a ' cooler ' flame, took a longer time to melt the solder. In soldering Method E, an electrically heated carbon point was applied to one wire and a clip to the other and it was found that the wire in contact with the carbon electrode was softened to a marked extent. Method D (electric ' soldering iron ' method) was the one where the most softening of the adjoining wire took place, possibly because the working area of the electrically-heated ' soldering iron ' was greater than needed for such a small joint; possibly also, with the wire being covered by the bulkiness of this appliance, it was more difficult to check visually.

3. A distance of 0·15 mm. between stainless-steel wires to be soldered did not alter the strength of the joint compared with those where the wires were in contact. This was unexpected but possibly if the distance had been greater this might have had a more marked effect on the tensile strength of these joints.

4. These experiments showed that, providing the soldering operation took only half a minute or so, the actual heating time was not an important factor in the softening of the stainless steel. As mentioned previously, the area of the heating source was possibly the most significant factor in softening the adjoining wire.

5. This series of experiments showed that the union between stainless steel and silver solder is more than a mechanical union since the strength of these joints could be stronger than the tensile strength of the silver solder joining the parts together. Microscopic examination of the joints showed that the fracture occurred not at the solder/stainless-steel interface but in the ' body ' of the solder. Under high-power microscopic examination there was not a sharp dividing line between the stainless steel and the solder but there was a ' third zone ' present where, quite possibly, some inter-alloying had taken place.

6. The experiments were not conclusive however on the subject of crevice corrosion at the point where a fine edge of solder met with stainless steel. This was probably due to the difficulty of experimentally producing any corrosion with plain water as the electrolyte.

In conclusion these experiments raised the interesting point of the ' voids ' present in the silver solder and further investigation would be necessary to show how these were brought about and how they could satisfactorily be reduced without over-complicating the soldering process.

Acknowledgements

Our thanks are due to Mr. Hudson, Instructor in Orthodontic Technique, and to our colleagues in the Metallurgy Department, especially Mr. Woodhead, for their freely given and expert advice.

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DISCUSSION

Mr. D. T. Hartley asked if Mr. Gardiner had any comment on the Easy-Flo flux in the standard grade as opposed to the stainless-steel grade. His own subjective impression was that he had not really been aware of any difference in their behaviour. In connexion with the flame used for soldering, had the authors included the butane-gas flame in their tests? If not, Mr. Hartley wondered if Mr. Gardiner would venture an opinion of the suitability of the flame and also of a small portable blow-lamp fuelled by iso-propyl alcohol using compressed air. Thirdly, on the point of crevice corrosion, did Mr. Gardiner think the differences between the polished and unpolished joints were primarily because of the mechanical shape of the point of junction or whether there was more to it than that. Would he give an opinion on whether or not it was desirable to electrically passivate stainless-steel parts after soldering? Mr. Hartley had heard it suggested that this was undesirable because it initiated crevice corrosion or, at least, accelerated its initiation.

Mr. Gardiner, in reply, said he was sorry they had not tested the differences between the standard and stainless-steel grades of flux. Nor had they had butane gas then available although he now had an excellent small butane burner of French manufacture called Flamidor. It was only about 19 cm. high and about 3 cm. in diameter. The iso-propyl alcohol flame burner was, he thought of Swiss manufacture, and named the P.D. Soldering Lamp. They found it quite effective. He regretted he could give no information on the point of crevice corrosion but they would certainly bear the point in mind in any further investigation.

RESEARCH REPORTS

THE PREVALENCE OF MALOCCLUSION IN A RANDOM SAMPLE OF 12-YEAR-OLD CARDIFF SCHOOLGIRLS. By E. M. Harkness, Dental School, Welsh National School of Medicine, Cardiff.

Out of a total random sample of 292 12-year-old Cardiff schoolgirls 216 have been analysed for the prevalence of malocclusion by examination of standard orthodontic study models. The study models were viewed on 3 different occasions and grouped according to Angle's classification. The occlusion of the buccal segments was recorded separately from the incisor segment occlusion. Final decisions were based on two agreements out of three. The Angle's Class I group was sub-divided into three sub-groups:–

1. Where less than a half molar unit deviation was postnormal.
2. Where less than a half molar unit deviation was prenormal.
3. Where no deviations occurred.

The findings indicate that amongst the children who did attend 93·5 per cent had an Angle's Class I buccal segment occlusion. There was 5·1 per cent Class II malocclusions and 1·4 per cent Class III malocclusions. Of the Class I group, 38·4 per cent were a half unit postnormal, 47·7 per cent had no deviations, and 7·4 per cent were a half unit prenormal. The incisor occlusions of the sample consisted of 93·5 per cent Class I cases, 3·2 Class II division 1 cases, 1·4 per cent Class II division 2 cases, and lastly 1·9 per cent Class III cases. Among the entire sample there were only 5 subjects who were considered to have an anatomically correct occlusion.

AN ASSESSMENT BY 4 OBSERVERS OF THE NEED FOR ORTHODONTIC TREATMENT IN A RANDOM SAMPLE OF 12-YEAR-OLD CARDIFF SCHOOLGIRLS. By W. A. B. Brown, A. J. P. Cousins, E. M. Harkness, and K. P. Isotupa,* Dental School, Welsh National School of Medicine, Cardiff.

Although orthodontists may largely agree that a particular case needs treatment, the reasons why they think treatment should be undertaken and what the treatment should be are not always clear.

To try and answer some of these questions 4 orthodontists examined 50 pairs of study models from a random sample of 12-year-old Cardiff schoolgirls. The examination was carried out in 3 stages with a week's interval between each stage.

Stage 1 asked the single question: Was treatment necessary? For 50 per cent of the sample one at least of the examiners disagreed outright or recorded that he was uncertain.

Stage 2 attempted to evaluate the basis for deciding if treatment was necessary. This evaluation was based on the following criteria: the aesthetics, the function, the degree of crowding, and the need for overjet treatment. For all these criteria there was a high level of disagreement or uncertainty, from 42 per cent for the need for overjet treatment to 66 per cent for the aesthetic evaluation.

Stage 3 tried to assess what treatment would involve. The observers considered the timing, complexity, and duration of treatment and whether or not appliances or extractions would be necessary. As for the first two stages, there was a high level of disagreement or uncertainty ranging from 50 per cent for the need for extractions to as much as 74 per cent for deciding the length of time treatment would take.

The value of using study models as an aid to testing examiner variability on apparently well established concepts is clear enough. However this study shows that their use alone for deciding upon or evaluating treatment plans is very limited and could be very misleading.

AN ANALYSIS OF FAMILIAL CHARACTERISTICS IN THE HUMAN DENTITION. By Rosaline Smallcombe and W. A. B. Brown, Dental School, Welsh National School of Medicine, Cardiff.

This study was prompted by the increasing interest taken in the role of inheritance in the establishment of the occlusion; it emphasizes and demonstrates how readily available material with the simplest procedures can be used to assist in identifying dental characteristics which may be under strong genetic influence.

From an examination of the study models of 14 families consisting of parents and at least 4 children, the following features were studied:—

1. The mesiodistal width of the upper permanent molars.
2. The accessory cusps of the permanent upper first molars and canines.
3. The malplacement of specific teeth and the nature of overcrowding.

It was found that within families there was a definite similarity in the size of the teeth and that the type of accessory cusps was recognizably associated with the families, as also was the pattern of malpositioned teeth.

A STUDY OF THE PREVALENCE OF MOLAR AND CANINE CROSS-BITES IN THE DECIDUOUS AND MIXED DENTITION. By J. F. Gravely, Lecturer in Orthodontics, Leeds Dental School.

The prevalence of molar and canine cross-bites was studied in 1287 children aged 3–8 years.

At 3–4 years the prevalence of cross-bites in boys was 6 per cent and in girls 12 per cent. At 7–8 years these values had increased to 18 per cent and 21 per

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cent respectively. In girls with cross-bites, 72 per cent affected canines and molars, 10 per cent affected molars only and 18 per cent affected canines only. The corresponding figures for boys were: 40 per cent, 21 per cent, and 39 per cent. In both sexes a normal lateral relationship of the canines was accompanied by a normal lateral molar relationship in approximately 97 per cent of instances. Approximately 87 per cent of cross-bites were unilateral in both sexes.

The intercanine widths of 71 children with a canine cross-bite were compared with those of 557 children who had a normal lateral relationship of the canines. The mean difference between the maxillary and mandibular intercanine widths (measured from the gingival margin on the buccal surfaces) was 6 mm. in those with a normal lateral canine relationship. The corresponding figure was 3 mm. in those children with a canine cross-bite. The mean maxillary and mandibular widths were consistently 1–2 mm. smaller in girls than in boys.

It is concluded that the prevalence of cross-bites in the buccal segment is affected by growth and it is postulated that in view of the association between molar and canine cross-bites, disparity in intercanine growth rates between the maxilla and mandible may be of aetiological significance.

A DIRECT/INDIRECT METHOD OF MAKING ORTHODONTIC BANDS

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THE technique described is based on the ' patch ' method of making orthodontic bands which is used by many operators. In order to save chair-side time, the preliminary stages are carried out on a model by the technician.

METHOD

Stage 1

Molar band blanks are made up from a 6·5 cm. length of 5×0·15 mm. stainless-steel tape. The pieces are welded into the form of a ring with an overlap of 3 to 4 mm. The ring is adjusted to fit into the Visick band-forming pliers and the ' neck ' where the band material is in contact is joined by one spot weld (*Fig.* 1).

The premolar and incisor band blanks are made from a 5·5 cm. length of 3·5×0·1 mm. tape. A twin tie channel bracket or similar bracket is welded onto the middle of the tape before it is formed to fit the Visick band-forming pliers. The operator should ensure that the bracket is welded onto the larger ring directly opposite the ' neck ' of the band blank (*Fig.* 2).

Stage 2

A model of the arch to be banded is made in artificial stone and a fine fretsaw is passed between the contact points of all the teeth. Where the saw passes through the gum, the gum is trimmed to make it easy to fit a band at the maximum convexity of the plaster tooth. Care must be taken that only plaster representing gum is removed so that the teeth are not reduced in diameter.

Stage 3

A band blank is placed in the Visick band-forming pliers and the band is placed over the plaster tooth. All the bands are pulled up from the lingual side except the lower molar bands which are pulled up from the buccal side. The band is burnished around the tooth and then the pliers are tightened to register the shape of the tooth at its maximum convexity. This operation is made easier if the movable catch on the band-forming pliers is removed.

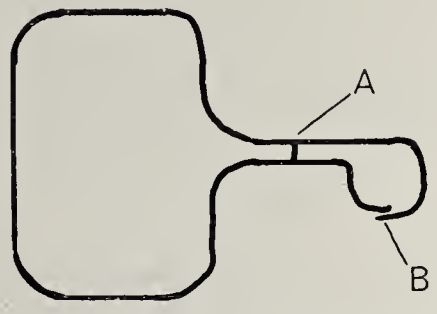

Fig. 1

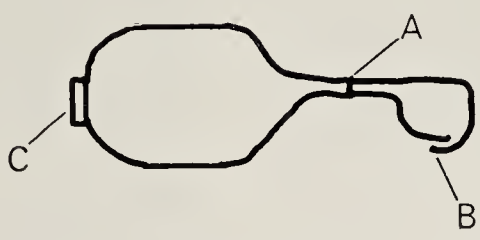

Fig. 2

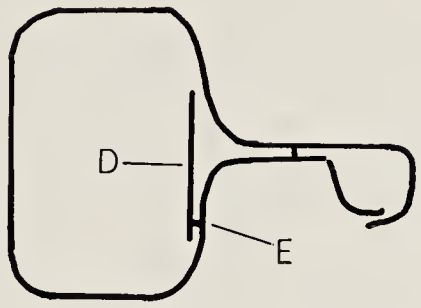

Fig. 3

Fig. 1.—A molar band blank ready for use in Visick pliers; (A) weld across neck to prevent slipping; (B) join in band material.

Fig. 2.—An incisor band blank; (A) weld across the neck of the blank; (B) join in band material; (C) bracket welded to blank.

Fig. 3.—Diagram of band blank after it has been fitted to the tooth, and patch of band material welded on one side of the join; (D) patch; (E) weld on one side of patch.

Stage 4

A patch of stainless-steel tape of the same dimensions as the band material is placed across the join of the band and welded on one side only (*Fig.* 3). The ends of the patch are cut off and trimmed with a wheel stone and at the same time the bands are lightly festooned. The upper molar band is festooned at the mesial gingival margin and the distal occlusal margin (*Fig.* 4). The lower molar band is trimmed on the gingival margin

Demonstration at the Country Meeting held in Leeds on 11 April, 1969.

mesially, lingually, and distally (*Fig.* 5). It is important that the band width is not reduced by more than 1 mm. The premolar and incisor bands are not festooned.

At this stage it is often desirable for the technician to fit the attachments to the molar bands and make the arches in order to save chairside time.

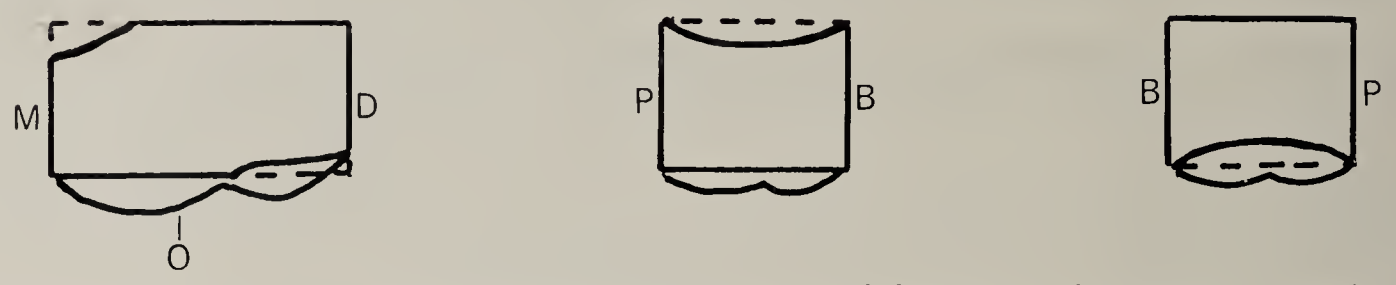

Fig. 4.—From left to right, a buccal, mesial, and distal view of a left upper molar band to show the trimming necessary. M—mesial, D—distal, B—buccal, P—palatal, O—occlusal.

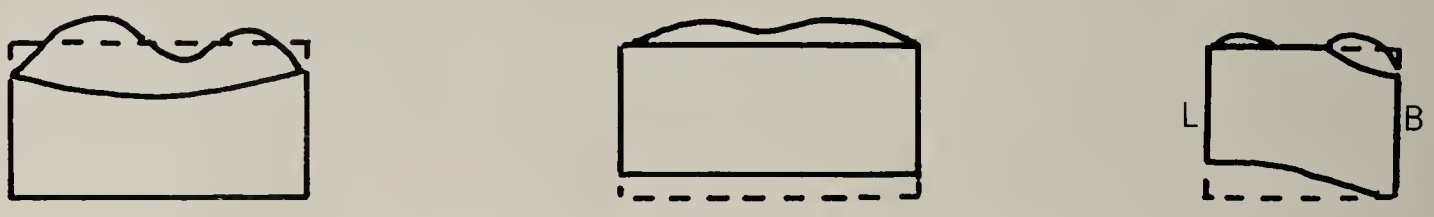

Fig. 5.—From left to right, a buccal, lingual, and mesial view of a lower molar band to show the trimming necessary. L—lingual, B—buccal.

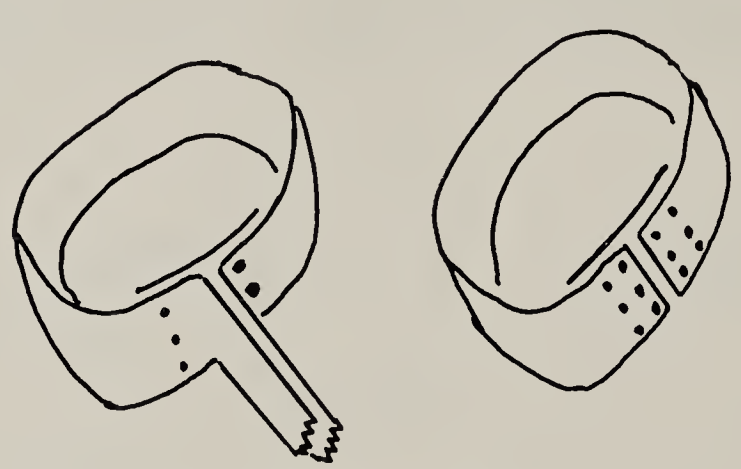

Fig. 6.—Showing how the band is welded and trimmed before final fitting.

The bands are then replaced on the teeth and refitted with the band-forming pliers.

On the lower incisors it may be easier to omit the patch and use a lapping technique.

Stage 5

When the patient attends for band making, any separation wires are removed and the preformed blanks are pulled up on the teeth with Visick band-forming pliers. Some operators may prefer to use incisor band-forming pliers for the incisors.

Stage 6

The band is finished by welding the other side of the patch, cutting off the surplus material, trimming the edges with a stone and re-welding the edges (*Fig.* 6). This stage may be done by the nurse or sent back to the laboratory for completion by the technician.

Stage 7

The completed bands are tried on to the teeth and any final adjustments made before the bands are cemented.

AN INVESTIGATION INTO THE EFFECT OF THE MAXILLARY BITE PLATE ON THE HEIGHT OF THE LOWER INCISOR TEETH

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MANY studies have been made into the effects of maxillary bite plates, but there have been very wide variations in the results reported. It is thought that these differences may have arisen from poorly defined experiments and inadequately defined samples.

This study attempts to reduce some of the variables involved, and concentrates on a small but strictly defined sample.

REVIEW OF THE LITERATURE

The clinical use of the bite plate has been recorded over a period of two hundred years yet assessment of its effects were difficult until it became possible to measure changes from serial cephalometric radiographs. However, despite the use of this technique for accurate measurement of growth and of treatment changes, there still exists appreciable variation in the findings reported by different investigators.

It is not relevant to the purpose of this paper to present an exhaustive review of the vast literature on bite plate effects, but the position was very well summarized by Salzmann (1950) when he stated in his textbook that ' whether elongation of posterior teeth or depression of anteriors takes place when a bite plate is worn is not fully settled '. Sixteen years, and several investigations later, the current edition (Salzmann, 1966) is more emphatic about molar eruption but still non-committal about incisor depression.

The uncertainty revealed is due not to lack of investigation, for numerous studies have been published, but much of the evidence is conflicting and it has proved impossible to compare data from the different studies because of the widely ranging criteria that have been used. The method and material may vary little between different experiments but there are wide variations within a single experiment for many of the factors—for instance, the time the appliance is worn, the stage of eruption, and the influence of growth, and the interval of time between cephalometric recordings. The time factor has proved to be of particular importance, and needs to be reviewed in more detail.

Belger (1956) took cephalometric radiographs of 12 cases at the beginning and end of bite plate wear but his treatment time, and consequently the interval between the radiographs, varied from a minimum of 1 month to a maximum of 11 months. Richardson and Adams (1963) studied 9 cases whose treatment time ranged from 2 months to 9 months but it was their oldest patient, aged 17 years, who showed both the quickest reduction of overbite (within 2 months) and also the greatest long-term stability.

Bahador and Higley (1944) studied 20 cases and their radiographs were taken at the beginning and end of the treatment period which varied from 2 to 8 months. The amount of overbite reduction was not recorded, but in 2 cases aged 10 and 11 years the clinically ' desired amount ' was obtained within 2 weeks.

Sleichter (1954) has made the most extensive study to date and he is the only writer who did stress the importance of the time factor. He underlined it in two respects. Firstly, he observed that, without control groups, ' there is no way

Presented at the Country Meeting held in Leeds on 11 April, 1969.

of knowing how much of the observed phenomena may be credited to growth and how much to eruption', but secondly, he found that there was great difficulty in making comparable measurements between the control and experimental groups because of the wide difference of time between films, which was of the order of years in the control group and of months only in the experimental group. He found it necessary to assume that eruption always took place at a constant rate for only then could one rely on comparable monthly increments.

Sleichter also focused attention on the growth and eruption complications—the difficulty in distinguishing purely treatment changes from those due to growth and eruption—but even so, his investigations failed to deal effectively with this problem. In his control group of 47 cases the ages extended from 6 years to 18, and the interval between radiographs from 10 months to nearly 10 years. His 30 treated cases ranged in age from 7 years to 14 and the treatment time from 4 months to 8 months.

Sleichter repeated his cephalometric films as soon as clinical changes became apparent, and at frequent intervals thereafter. In 10 out of 16 treatment cases the first film was taken at the end of 1 month of treatment time, and there are 15 cases in all where cephalometric measurements are available for a treatment period of not more than 3 months. The short interval of time between successive films will make it possible to compare his findings with those of the present study.

The literature shows that substantial clinical change of incisor overbite can occur in response to a maxillary bite plate within a period of two months and this is fully confirmed by the present study. Growth changes over this period must be small. In any investigation, the shorter the period of treatment, the greater will be the proportion of change due to that treatment.

The present contribution attempts to reduce the variables of dental age, the type of appliance, the duration of treatment, and the method of recording experimental change. The time limits, in particular, are strictly defined so as to more rigorously test the hypothesis.

HYPOTHESIS

The hypothesis is made that a maxillary bite plate reduces the lower incisor height within the initial 2 months of appliance wear.

MATERIAL

The sample consisted of 7 boys and 7 girls. Their ages ranged from 13 years 6 months to 15 years 10 months for the boys, and from 11 years 7 months to 17 years 9 months for the girls, but they were closely comparable in eruption status, the premolar and canine teeth being in full occlusion.

Clinically it was stipulated that:—

1. The reduction of incisor overbite was part of the treatment plan.
2. The overbite was such that at least 50 per cent of the lower incisor teeth were overlapped by the upper incisor teeth.
3. The lower incisor teeth occluded either with the upper incisor teeth or the palatal mucosa.
4. The incisal surfaces of the lower incisors teeth were level.

All cases were skeletal Class II, assessed on the basis of the difference between SNA and SNB angles, with a range of 4·5–8·5° and a mean of 5·5°.

Eleven cases, 6 boys and 5 girls, were assessed as Angle's Class II, division 1. Three cases, 1 boy and 2 girls, were assessed as Angle's Class II, division 2.

METHOD

Design of Bite Plate

1. Maxillary acrylic resin base plates were made with the addition of bite planes parallel to the occlusal plane, as observed from the study models. Adams's clasps were made for the first permanent molar teeth but there were no other attachments (*Fig.* 1).

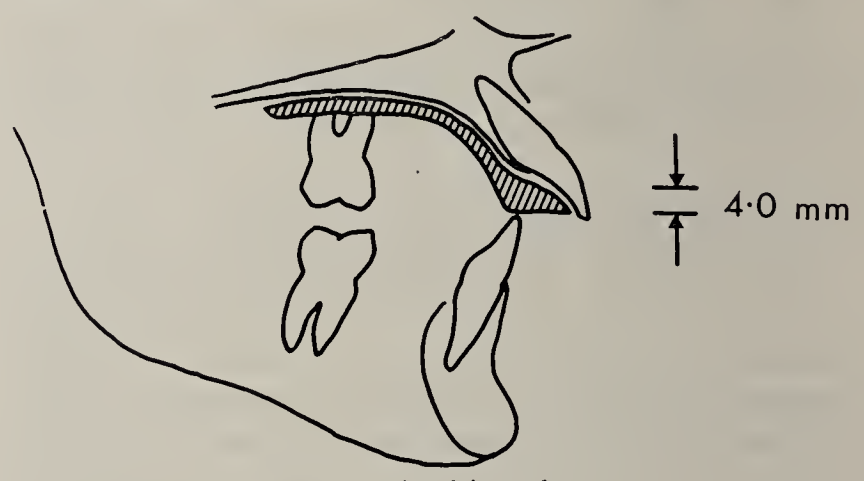

Fig. 1.—The bite plate.

2. The bite plane separated the incisal surfaces of the lower incisor teeth by a distance of 4 mm. from their previous occlusal or mucosal contact.
3. The patients were instructed to wear their appliances at all times, including meals, with the exception of removal for cleaning.

Cephalometric Record

Three lateral cephalometric radiographs were taken for each patient, the first when the appliance was fitted, the second 2 weeks later, and the third 6 weeks later again when the appliance had been worn for 8 weeks altogether.

Cephalometric Technique

Some details of the cephalometric technique are included because the changes described in the

findings are of very small dimensions and must be related to some extent to the confidence in the accuracy of the technique and equipment used.

An Adams cephalostat was used at an anode–target distance of 5 ft. (Adams and Brown, 1966). Exposures were made at 200 kV. and 98 mA. using high definition screens and a Siemens grid with a grid ratio of 12:1. The bite plate was removed from the mouth before each radiograph was taken and the patient was instructed to close into centric occlusion.

Fig. 2.—Lower incisor height.

Measurement

Two transparent measuring sheets, as described by Björk and Solow (1962), were placed directly on to the lateral cephalometric films and were orientated one to the mandibular plane, as described by Downs (1948), and the other to the perpendicular which passed through the tip of the most prominent lower incisor tooth. The lower incisor height was recorded as the distance between the mandibular plane and the parallel to that plane which passed through the uppermost point of the lower incisor tooth (*Fig.* 2). This distance was measured with a modified Boley gauge to a unit of 0·1 mm. The decision to work to a unit of 0·1 mm. was due in part to Björk's (1947) work in which he found that of all his cephalometric linear measurements, the lower incisor height had one of the smallest degrees of error. The findings are based on smaller dimensions than are sometimes considered reproducible, and statistical tests were made to assess the error of the method. Each film was measured twice: after the first measurement the films were shuffled to randomize them before they were measured the second time. Double determinations were made of the measurements from the first and last films of all 14 cases. A total of 56 measurements, therefore, were analysed statistically. *Table I* gives the mean differences, the range of the differences, the standard deviations, and the coefficients of variations.

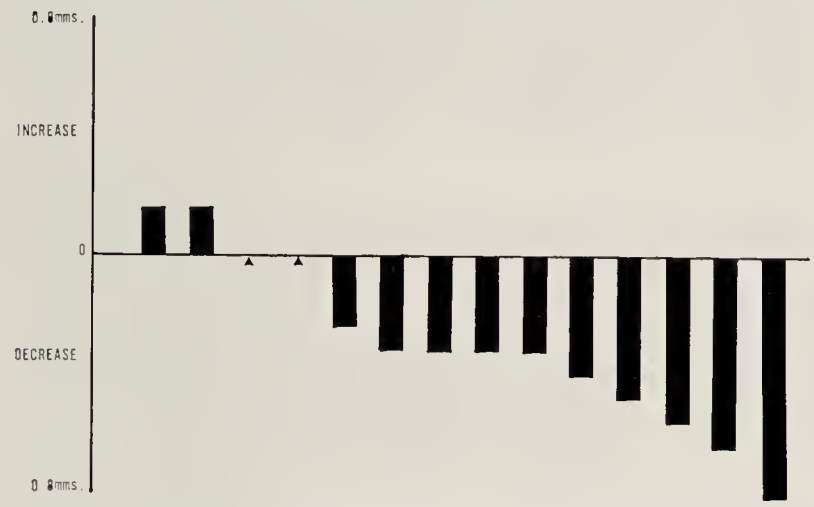

Fig. 3.—Changes in lower incisor height after two months wearing of a bite plate.

Table I.—Lower Incisor Height Measurement: Error of the Method (N=14)

Film Series	Mean Difference	Range		Standard Deviation	Coefficient of Variation (per cent)
		Minimum	Maximum		
First	+0·007	−0·1	+0·1	0·083	0·1
Last	−0·014	−0·1	+0·1	0·086	0·2

FINDINGS

At the end of two months of appliance wear, 2 of the 14 cases showed an increase in lower incisor height, 2 cases showed no change, and 10 cases (71 per cent) showed a decrease in height.

Table II.—Changes in Lower Incisor Height after 2 Months Wearing a Bite Plate

Case	*Incisor Height*	*Case*	*Incisor Height*
1	+0·2	8	−0·2
2	+0·2	9	−0·2
3	0·0	10	−0·3
4	0·0	11	−0·4
5	−0·1	12	−0·5
6	−0·2	13	−0·6
7	−0·2	14	−0·8

These changes are illustrated by *Fig.* 3 and the precise figures are given in *Table II.*

The small dimensions of the changes must be stressed, the unit of measurement being only 0·1 mm.

An analysis for significance of the findings was made and is summarized in *Table III*. This shows no significance in the differences of the double determination measurements of either the first or the last set of films, but a high level of significance was found in the differences between the first and last sets of films. These treatment changes are significant to the 0·1 per cent level.

Table III.—Results of Analysis for Significance of Findings

Film Series	*Significance*
First	Double determinations not significant
Last	Double determinations not significant
First–Last	Treatment change significant

Clinical overbite and molar height changes were measured to a unit of 0·5 mm. All cases showed a reduction of overbite, ranging from 1·0 to 3·5 mm., with a mean of 2·2 mm. Molar height increased in all cases, the increase being greater in the lower arch than the upper, and greater among the boys than the girls.

DISCUSSION

Clinical experiments are characterized by the difficulty of controlling the many variables that inevitably arise, but a particular effort has been made in the present study to reduce these variables as much as possible.

The dental age has been emphasized as it seemed to be more relevant than the chronological age. The stipulation that all premolar and canine teeth should be in full occlusion was not met below the age of 11 years 7 months in the girls and 13 years 6 months in the boys.

The design of appliance has been standardized and the method of measurement has been described.

Very close limits have been set for the duration of appliance treatment, the timing of the cephalometric records, and for the unit of measurement.

The restriction of the investigation to a period of treatment of only 2 months limits the changes due to eruption of teeth and to growth of the maxilla and mandible, but is not too short a period to observe measurable treatment changes.

In most of the investigations recorded to date, it appears that the maximum effect of the bite plate is obtained in some cases within a few weeks of fitting, and our own findings support this.

Longer intervals between cephalometric films are not only less precise in differentiating between growth and treatment changes but can also be misleading. The effect of the bite plate is dependent upon separation of the molar teeth. This effect is lost as soon as the separated molar teeth have re-established even limited occlusion, and it has been shown that this point can be reached within a very few weeks.

Sleichter (1954), who took radiographs at frequent intervals, found that in the majority of his cases the initial effect of the bite plate was to cause a slight reduction of lower incisor height but that this change was reversed as soon as molar occlusion was restored. Over a period of 6 months of appliance wear, a particular case might show an increase of lower incisor height of 0·1 mm. but study of intervening cephalometric films might show that a reduction of height of 0·3 mm. occurred initially, during the first 2 months, but that, after molar occlusion was restored, this initial decrease was followed by an increase of 0·4 mm. over the subsequent 4 months. Thus a change of 0·3 mm. followed by a change of 0·4 mm. in the reverse direction could be measured as a total change of 0·1 mm. only, and the actual change recorded would depend upon the time at which it was made.

The time taken for molar occlusion to be restored varies widely from case to case, but it is evident that comparison between cases is valid only if a sharp distinction is made between those measurements taken before or at the restoration of molar contact, and those taken after the restoration of molar contact has occurred.

This factor could account, to some extent at least, for the poor comparability found between previous studies of the effects of bite plates—studies in which the treatment times are both longer and more varied and in which the intervals between successive cephalometric films are not standardized. On the other hand, a relatively close comparability does emerge between the present study and the one other investigation in which the recording times are similar, i.e., the 15 cases of Sleichter (1954) in which there was not more than 3 months between the first and a subsequent cephalometric radiograph. *Fig.* 4 shows the percentage of increase and decrease of incisor height over treatment periods of 2, 3, and 8 months. The general pattern of results is very similar, but it can be seen also that as the interval between measurements is reduced, so there is a consistently higher proportion of cases showing a reduction of incisor height.

The level of comparability depends upon the unit of measurement as well as the accuracy of measurement. The present study confirms the practicality of working to a unit of 0·1 mm. but if a unit of 0·5 mm. had been taken instead, only 3 out of 14 cases would have registered a treatment change.

While the changes in lower incisor height found in this study agree closely with those cases of Sleichter in which comparable data is available, there is at the same time a good agreement with virtually all the previous studies with regard to the changes observed in clinical overbite and in upper and lower molar heights.

If these larger changes, which are adequately measured by a unit of 0·5 mm., show no discrepancy, then the clinical behaviour of the various samples must be comparable; it seems reasonable to suppose that similar changes in lower incisor height might have occurred in all the samples, but that they were not recorded either because the changes were too small, or because the interval between radiographs was too long.

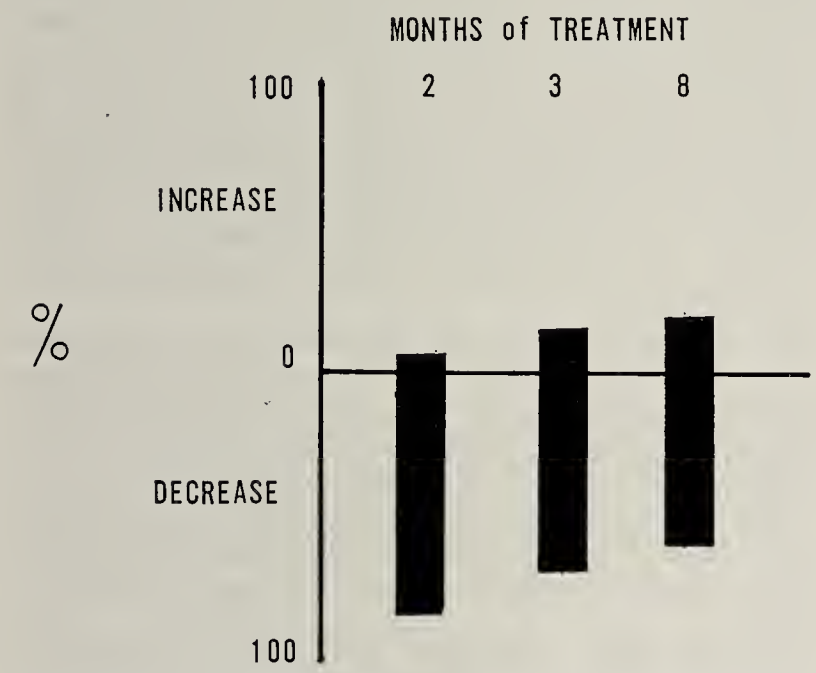

Fig. 4.—Changes in lower incisor height after 2 months of wearing a bite plate compared with changes after 3 and 8 months in Sleichter's study.

CONCLUSION

Over a treatment period of 2 months it was found that a maxillary bite plate reduced the lower incisor height in 10 cases out of 14. The findings were tested statistically and found to be significant to a high level. It was confirmed however, that the amount of change of lower incisor height was very small in proportion to the change in clinical overbite.

It is suggested that accurate assessment of the effect of a bite plate depends firstly upon a very short interval of time between serial cephalometric records and secondly upon a sufficiently small unit of measurement.

SUMMARY

An investigation has been made into the experimental design needed to measure the effect of a maxillary bite plate upon lower incisor height. Small but significant changes have been found, and the lack of comparability between previous investigations in this field is thought to be due to variation in experimental procedures.

Acknowledgements

Grateful acknowledgements are made to Mr. Peter Sweetnam of the Epidemiological Unit, Medical Research Council, Cardiff for supervision of the statistical analysis, and to Miss P. Martin and to Mr. B. A. Jones for the illustrations.

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DISCUSSION

Mr. C. D. Parker said that, in his own investigations of Class II, division 1 cases with deep overbites treated with bite plates, he had found a similar pattern of response. However, at the end of treatment in the 12 cases studied only 2 cases showed depression of the lower incisors. Two other cases showed no change in height of these teeth and in the remaining 8 cases the height of the lower incisors had increased. Comparing these findings with those of Mr. Cousins, it would suggest that in most cases the initial depression which usually occurs is frequently lost. The probable explanation for this was growth rather than variation in technique. The fact that even in the short term there is this varying response with some lower incisors depressing and some not creates the need to predict the individual response. Could Mr. Cousins predict the cases where depression of lower incisors would occur?

Mr. Cousins said that the paper was strictly limited to answering a particular question. Unfortunately, most of the cases went on to multiband appliances. They did not know much about the long-term effects, and he could not spot the ones which would depress. Perhaps one of the findings was that if one was going to open the bite with a bite plate it would probably be done very quickly or not at all.

Professor W. J. Tulley asked whether taking a constant 4-mm. separation of the incisors from their contact was valid in view of the fact that in some instances the lower incisors might show increased eruption. Would it not be better to have opened the bite by a constant amount in the buccal segment?

Mr. Cousins replied that the figure was arbitrary because it was simpler to be arbitrary. It was true that for each case there were individual differences.

Dr. J. D. Atherton wondered whether Mr. Cousins was misleading them in pursuing the question of depressing the lower incisors, because what he had said in effect was that the bite plate did not depress the incisor to any significant extent—only 0·8 mm. What in effect was being done was to allow the molars to erupt, and that was what all bite plates did, particularly if they were left in for a period of time.

Mr. Cousins agreed. They had not found any fresh clinical evidence, but they had settled some confusion which had arisen as to whether bite plates did depress the incisor teeth at all.

Mr. N. Upson asked whether the authors actually depressed the incisors or altered the inclination.

Mr. Cousins replied that he was unable to find any significant alteration in incisor angulation. It was difficult to measure it accurately, but all the changes were found to be within the error of the measurement.

Mr. Upson asked whether the models were articulated.

Mr. W. A. B. Brown replied that they had trimmed their study models according to Mr. Adams's technique which was as near as possible to producing a standard approach to study models.

Mr. W. A. Nicol asked if it would not have been better to make some measurement of the facial height rather than the anteroposterior relationship, because what one was dealing with was vertical dimensions, not anterior-posterior dimensions. In the case of the 2 results that behaved peculiarly, where there was elongation rather than depression, what were the maxillary–mandibular planes angles?

Mr. Cousins replied that when he had found that there were two odd ones, he had tried to see if there was any pattern. He had failed to find any pattern at all, or any correlations.

Dr. J. D. Atherton, taking up the point made by the previous questioner, said that he had looked into this problem himself (*Br. dent. J.*, **114**, 512, 1963). In broad terms, the net effect of wearing a bite plate was to open the maxillary–mandibular angle, and increase the lower facial height.

Mr. L. W. Russell said that the author had mentioned the lack of controls. Might one not do this by having a similar bite plate, but with the molars also covered, so that they could not erupt further?

Mr. Cousins said he had not thought of that.

Mr. C. D. Parker said that there were cases where depression of the lower incisors was essential if a stable correlation of the incisors was to be achieved. Depression of lower incisors became more of a problem as the patient became older, and growth was no longer there to help. This situation was probably the reasons why multiband appliances were used in older patients and bite plates in the younger ones.

Mr. J. G. Stephenson asked whether the authors had found any evidence of the depression of the upper incisors.

Mr. Cousins said that he had looked at the effect on the upper incisor teeth, but it was very much more difficult to measure. In one case, the upper incisor teeth showed an appreciable tilt, but there was no change which was worth analysing.

Mr. Stephenson said he presumed the appliance did not incorporate a labial bow or incisal tip cleats.

Mr. Cousins replied that that assumption was correct.

Mr. Nicol asked whether, in the 2 peculiar cases, the author had any proof that the appliances were worn.

Mr. Cousins said it depended what was meant by ' proof '. They had no reason to doubt it, and all the patients were under treatment subsequently.

Mr. J. J. Crabb asked the author to comment on his statement that the lower molars erupted more than the upper molars.

Mr. Cousins replied that this had been consistently found in all the studies. It was found in every case that the eruption of the lower molars was greater by an appreciable amount than that of the upper molars.

TOOTH SIZE AND CLASS DISTINCTION

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An investigation was planned to discover if there is a higher proportion of large teeth in some classes of malocclusion than in others, using the width of the upper central incisors as an index of the size of all the teeth in both arches.

DEFINITIONS

In deciding Angle's classification of the dental arches in occlusion, correction was first made for drifted teeth. The Class I relationship was that in which the lower incisors occluded, or would occlude, with the middle third of the palatal surface of the upper incisors and the other teeth presented or would present an ideal occlusion of cusps with fossae and embrasures. In Class II the lower incisors occluded or would occlude higher on the palatal surfaces of the upper incisors and the lower dental arch was more posteriorly placed relative to the upper. In Class III the lower arch was more anterior than in Class I

The skeletal class was assessed clinically after Ballard (1948). If with their axes 'corrected' the lower incisors appeared to occlude with the middle third of the palatal surfaces of the upper incisors a skeletal Class I or Skeletal I, was recorded. In Skeletal II the lower incisors appeared to occlude higher on the palatal surface of the upper incisors, and the reverse in Skeletal III.

The definition of competent lips has been clearly given by Ballard (1956). With the mandible in its endogenous postural position and with the muscles of facial expression in resting posture, the lips are in contact maintaining an anterior oral seal.

Ballard's (1963) observation that a considerable proportion of the population with lip incompetence have probably never had a lips apart posture, is a great help toward interpreting the behaviour of muscles and makes one hope that those who understand soft-tissue behaviour will help us more certainly to detect, describe, and define the posture of an individual that is 'built in', that which is apparent, and that which is likely to result from orthodontic interference.

My patients sitting upright but apparently relaxed and with an anterior oral seal were described as having competent lips.

MATERIAL

The clinical notes of the last 2000 patients aged 6–18 years with dental malocclusion to come to my practice, and the last 500 pairs of plaster casts in my model store, were used. The dental measurement recorded was the largest mesiodistal dimension parallel to the labial (or buccal) surface and parallel to the incisal edge (or occlusal surface), after Seipel (1946). The plaster models which were cast from alginate impressions were measured to 0·1 mm. Intra-oral measurements, of upper central incisors only, were made to 0·05 mm. Also recorded on the data cards for the computer were each individual's sex, Angle's classification, skeletal classification assessed clinically, and lip competence or incompetence.

The information from the 500 pairs of plaster casts and the information from the 2000 clinical examinations were assessed separately. At the 95 per cent confidence level the precision of a single measurement equalled 0·154 mm. for the plaster casts investigation and 0·18 mm. for the clinical investigation. The '*t*' test for bias between the first and second measurements was not significant in either case.

RESULTS

The Comparability of Clinical and Laboratory Measurements

The clinical measurements of 540 maxillary central incisors were compared with the measurements of the same teeth obtained from plaster casts. The standard deviation was 0·07 mm. The average difference between the measurements was 0·0084 mm., indicating a slight bias for the clinical measurements to exceed the plaster cast measurements. Warrer (1952) compared clinical and plaster casts measurements of mandibular incisors and found a standard deviation of 0·08 mm.

His figures and mine would appear to justify the comparison of clinical and plaster cast measurements. When the incisors overlap or are rotated, they are more difficult to measure clinically than on models, so one should not assume that the clinical measurements are necessarily more nearly true than those obtained from plaster models.

Read by title at the Country Meeting held in Leeds on 11 and 12 April, 1969.

Variability in Tooth Width

From the study of the 500 pairs of plaster casts a considerable range of size was found for every tooth. Lower incisors ranged over 1·8 mm., first molars over 3·0 mm., and upper second incisors over 4·5 mm. In nearly every case the extremes of the range were represented by single teeth.

In the case of every tooth back to the first permanent molar the average size for the girls was slightly but significantly less than the average size for the boys.

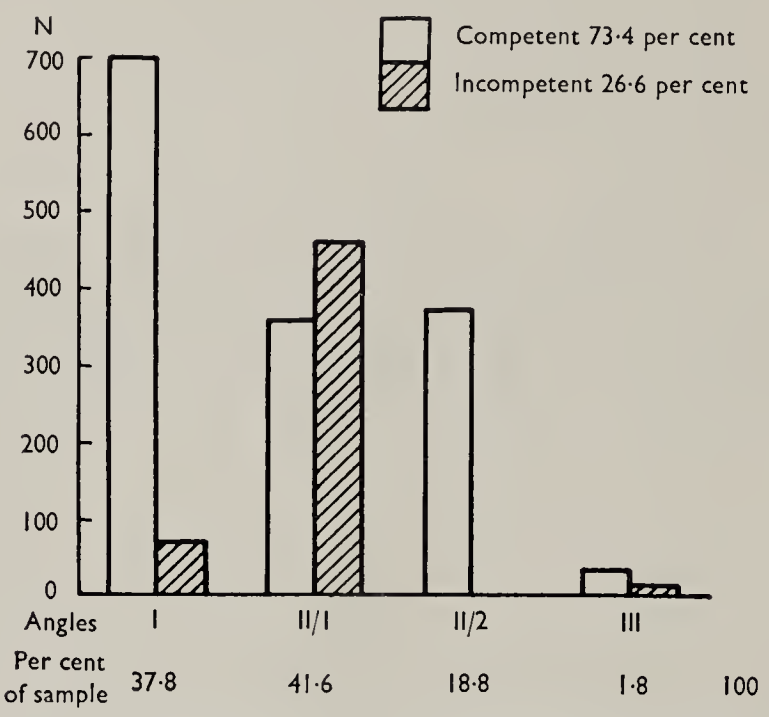

Fig. 1.—The distribution of malocclusion classes showing lip competence.

The Incisal Index

The width of the upper lateral incisor expressed as a percentage of the upper central incisor is the incisal index. Figures quoted by Selmer-Olsen (1949) suggest that in some races, for example the Japanese and the Hungarian, the incisal index is greater in the male than in the female. From the plaster casts of 181 boys an incisal index of 77·3 was calculated. For 319 girls the incisal index was 77·46. That is, in these 500 malocclusions the incisal index, on the average, was not greater for the males.

Distribution of Malocclusion Classes

Many workers have reported on the incidence of malocclusion in schoolchildren generally, including Korkhaus (1928), Taylor (1935), Sclare (1945), Massler and Frankel (1951), Walther (1960), Tulley (1964), Emrich, Brodie, and Blayney (1965). The distribution of malocclusion in groups of children referred to them for treatment have been reported by Hooper (1966) and Rose (1966).

Fig. 1 shows the distribution of Angle's classes of malocclusion in the sample of 2000 and their separation into those with competent and incompetent lips. The number of Class I malocclusions with a lips apart posture is comparatively small, 9·3 per cent. Presumably this is because the combination of large teeth and/or a Skeletal II tendency with other aetiological factors in such a case would make it develop into a Class II, division 1.

Just more than half, 55·4 per cent, of the Class II, division 1 malocclusions had a lips apart posture. Class II, division 2 malocclusions do exist in combination with a lips apart posture but none was found in this sample.

Fig. 2 shows that approximately two-thirds of the Class I malocclusions in the sample had

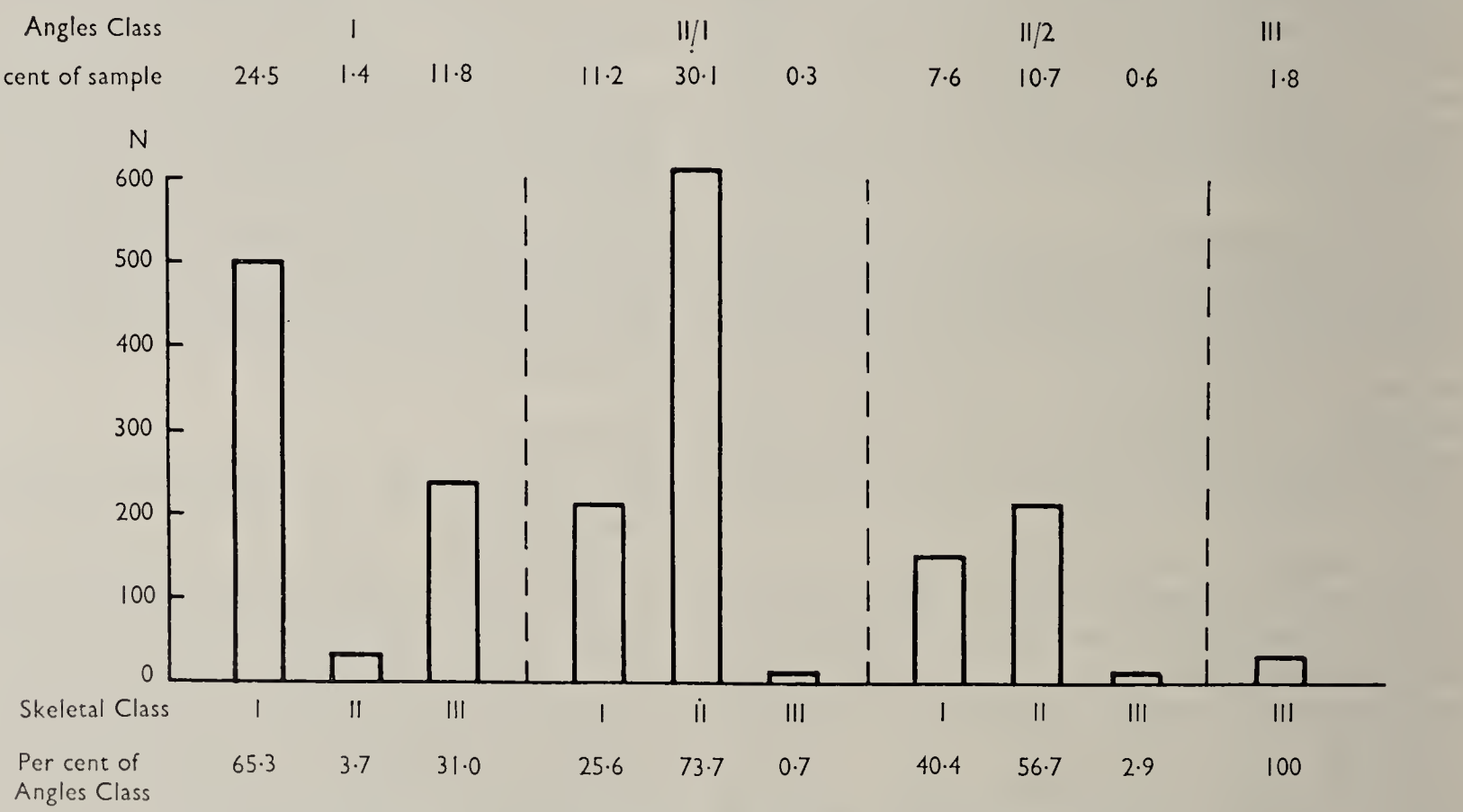

Fig. 2.—The distribution of skeletal classes within each of Angle's classes.

Skeletal I bases. An appreciable number, 31 per cent, of the Class I malocclusions had a Skeletal III relationship (11·8 per cent of the sample). These were individuals who had the lower supporting bone well forward but achieved a modest incisal overlap (overbite). Less than 4 per cent were Skeletal II. When other aetiological factors such as tooth-bone proportions

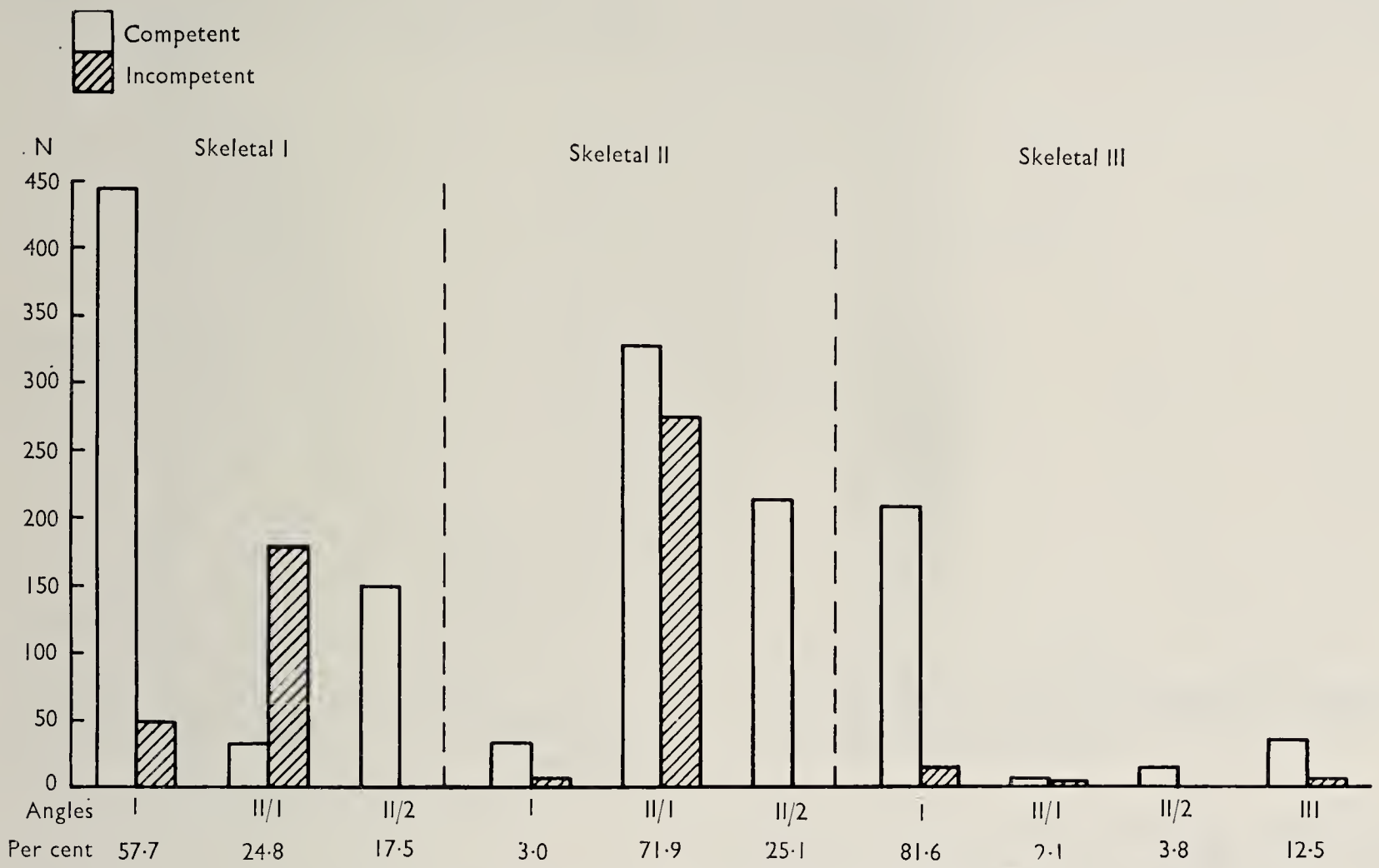

Fig. 3.—Angle's classes divided among skeletal classes.

and soft-tissue morphology are at all unfavourable it must be more likely for a Class II than a Class I malocclusion to develop on Skeletal II bases. This is borne out in *Fig.* 2 where 73·7 per cent of the Class II, division 1 malocclusions in the sample are shown to be Skeletal II. Relatively large teeth would encourage a forward movement of the dental arches (Ballard, 1956), and incompetent lips might permit a forward movement of the upper arch. The lower lip might even restrain or retrocline the lower anterior teeth. Moderately strong competent lips restraining teeth with Skeletal II bases are likely to cause a high angle of incidence of upper and lower incisors and so produce a Class II, division 2 malocclusion.

Although the majority of Class II, division 2 malocclusions had Skeletal II bases there were 40 per cent with Skeletal I bases, and a minority with Skeletal III.

Distribution of Skeletal Classes

Investigations of the anteroposterior relation of the skeletal supporting bone of the dental arches have been reported by Leech (1958) from an upper respiratory clinic and Cryer (1965) from a study of 1000 London schoolchildren. Their figures were approximately the same with 60 per cent of Skeletal I, 30 per cent of Skeletal II, and 10 per cent of Skeletal III.

The results (Beresford, 1967), from the sample of 2000 children with malocclusion, whose skeletal classes were assessed clinically are compared below with those obtained by Blyth (1959) who traced the radiographs of 200 patients with malocclusions (a random selection) at the Eastman Dental Hospital, London.

	Results	
	Blyth, 1959 (per cent)	Beresford, 1967 (per cent)
Skeletal I	33·5	43·3
Skeletal II	48·0	42·3
Skeletal III	18·5	14·4

In the children with malocclusion we both found more examples of Skeletal II and fewer of Skeletal I than did Leech and Cryer whose samples had not been selected as having dental malocclusion. Walther (1960) made an extensive study of 1000 East Anglian schoolchildren, and his example of checking clinical assessments against X-ray tracings for small groups was followed in my investigation. If Walther's mild and definite relationships are combined 53·3 per cent of the East Anglian children were Skeletal II.

It would be a mistake, therefore, with our present knowledge, to assume that children with malocclusion include more Skeletal II's than does the child population at large.

Just over half the malocclusions with a Skeletal I relationship in my sample were Angle's Class I and 90 per cent of these had a lips together posture (*Fig.* 3). Of the 213 Class II, division 1 malocclusions on a Skeletal I base 85 per cent had a lips apart posture. The 15 per cent with a lips together posture consisted of children with an anterior tongue thrust, sometimes reinforced by a digit sucking habit, or mild and unilateral malocclusions.

Among the Skeletal II malocclusions there is a preponderance of Angle's Class II. Of the Class II, division 1 Skeletal II malocclusions in *Fig.* 3, 54 per cent showed a lips together posture.

The Skeletal III malocclusions included a majority of Angle's Class I and a small number of every other Angle's class of malocclusion.

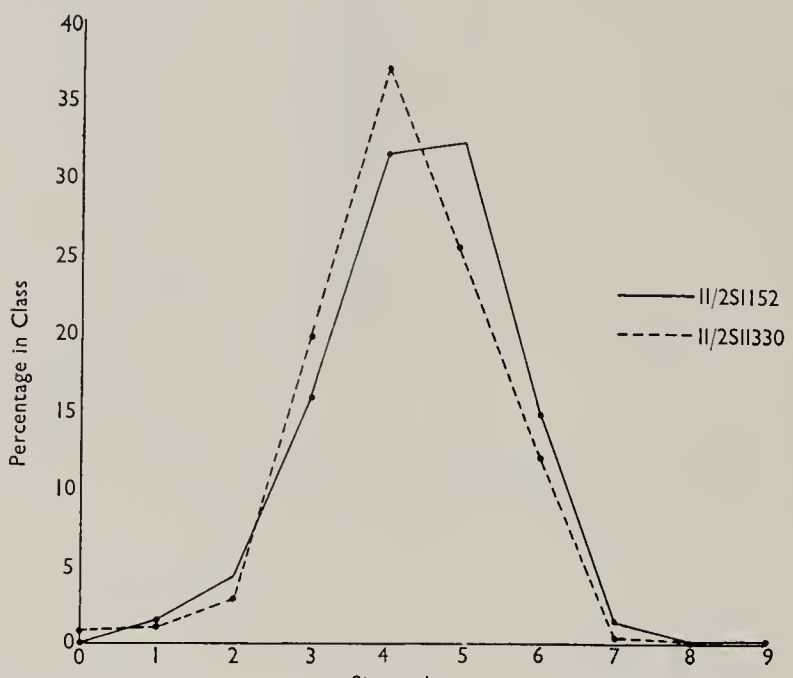

Fig. 4.—Distribution of Class II, division 2 malocclusion with different tooth sizes.

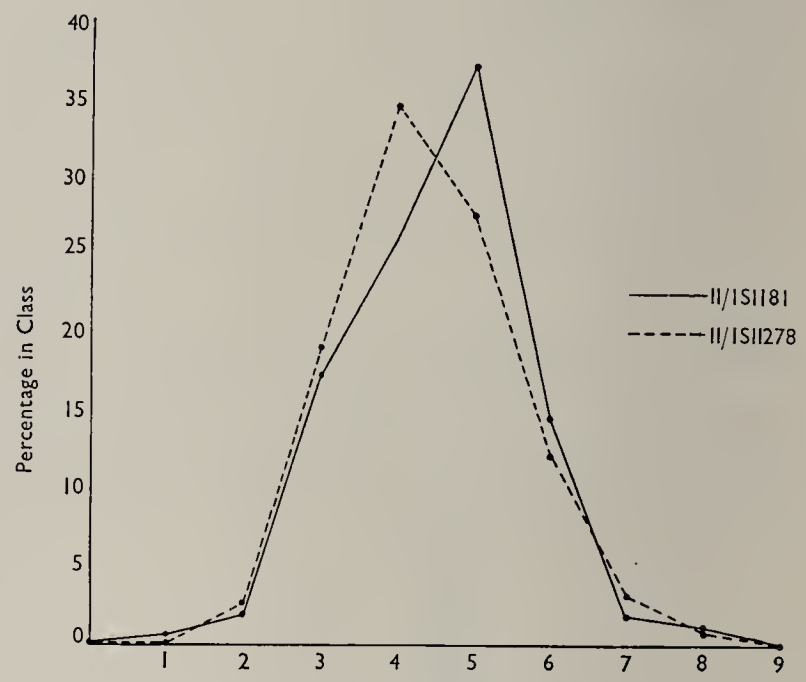

Fig. 5.—Distribution of Class II, division 1 malocclusion with incompetent lips and different tooth sizes.

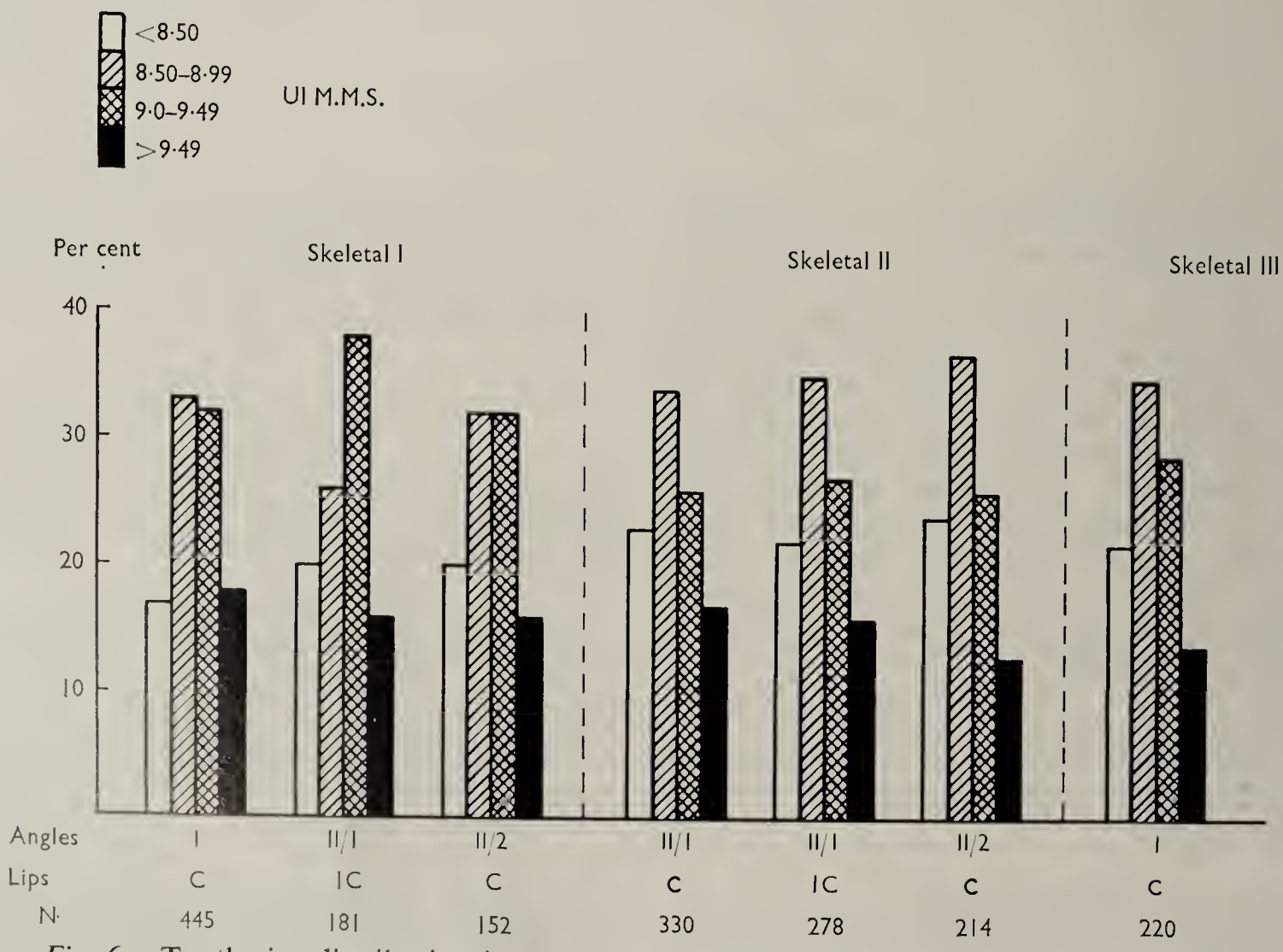

Fig. 6.—Tooth size distribution in malocclusion classes with more than 150 individuals.

Tooth Width Correlation in Malocclusion

Drennan (1929) drew attention to the fact that individual teeth in an otherwise high or low series can assume an altogether anomalous position. Most of us have observed patients having one or two teeth whose size is out of proportion to the size of all the other teeth in their dentition. Lundström (1960) concluded that ' the genes determine the sums of the diameters of the teeth to a high degree of precision '.

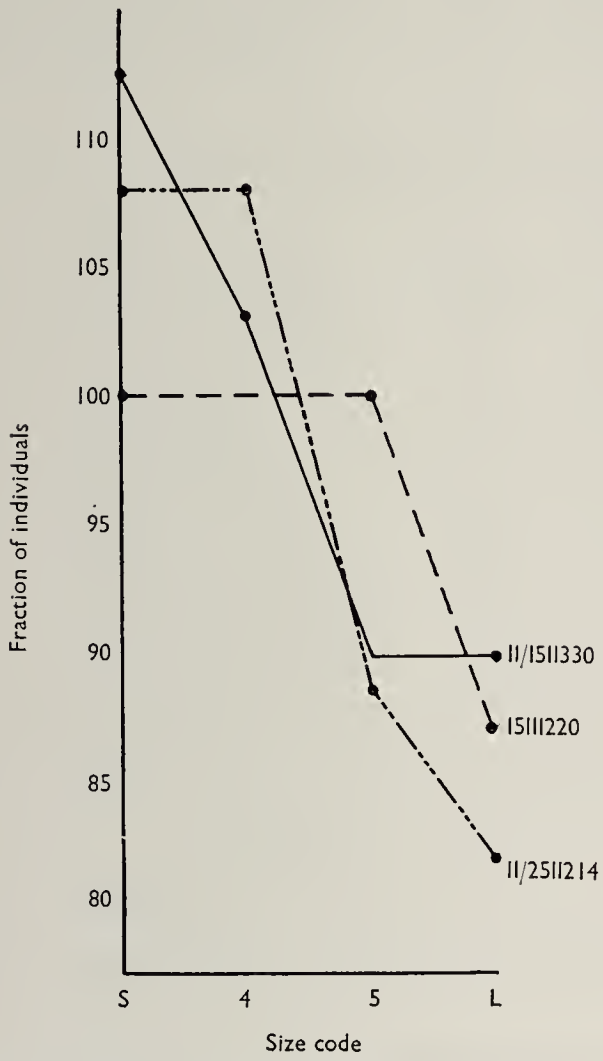

Fig. 7.—After adjusting for the overall numerical strength of malocclusions a tendency is seen for some malocclusions to be represented more by those who have small teeth.

Several workers, including Ballard (1944), Seipel (1946), Clinch (1963), and Moorrees and Reed (1964) have demonstrated the correlation in size of the various teeth of any individual. The groups studied were selected for various reasons such as their availability. As my study was based exclusively upon patients with malocclusion it was necessary to confirm the coefficients of correlation for such patients. This was done from the plaster cast measurements and with reference to the upper central incisors as these would be the easiest teeth to measure clinically. The calculations were based upon the average width of the antimeres (the same teeth on opposing sides of the arch) as recommended by Moorrees and Reed (1964).

Medium coefficients were obtained when the widths of all the upper and lower teeth, as far as the first molars, were compared to the upper central incisor width in the 500 pairs of plaster casts. The upper central incisor showed a higher coefficient of correlation with the (near by) lower anterior teeth ($r=0{\cdot}68$) than with the posterior teeth of either jaw ($r=0{\cdot}50$). The next highest figure was for the upper second incisor ($r=0{\cdot}58$) although the range in size for that tooth was great, 4·1–8·6 mm. (congenital absence was excluded from the calculations). In clinical work it seems to be the extremes of variation which impress us for the human upper second incisor has a reputation for being very variable.

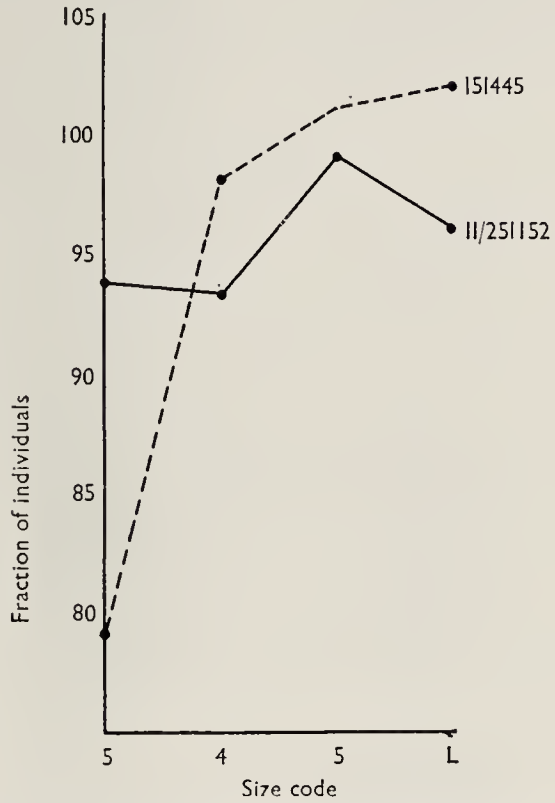

Fig. 8.—After adjusting as in *Fig.* 7 it is seen that some malocclusions are represented more by individuals with large teeth.

There was a definite, although not tight, relation between the size of the upper central incisors and the size of the other teeth in the 500 children with malocclusions. This relation can still be demonstrated when the malocclusions are divided into Angle's Class I and Angle's Class II. Medium coefficients of correlation were still obtained when the malocclusions were divided further into Class I Skeletal I, and Skeletal III; Class II, division 1, Skeletal I and Skeletal II; and Class II, division 2, Skeletal I and Skeletal II.

Tooth Size and Class of Malocclusion

The individuals in the sample were grouped according to the size of their central incisors. The groups were coded at 0·49-mm. intervals. Code 0 was for first incisors of an average width less than 7·0 mm. Code 1 was 7·0–7·49 mm. and so on to Code 9 which was for teeth 11·0 mm. or more in width (*Figs.* 4, 5).

In most classes of malocclusion there proved to be scores, or even hundreds, of individuals represented by size Codes 4 and 5 but only 1 or 2 individuals in size Codes 1 and 8. In the whole

Table I.—Tooth Sizes in Malocclusion: Competent Lips

Occlusion		Code M–D Width (mm.)				Total
		S (<8·5)	4 (8·5–8·99)	5 (9–9·49)	L (>9·49)	
Angle's Class I, division 1:						
Skeletal I	Number	74	147	142	82	445
	Per cent	17	33	32	18	
Skeletal II	Number	7	8	6	4	25
	Per cent	28	32	24	16	
Skeletal III	Number	49	76	64	31	220
	Per cent	22	35	29	14	
Angle's Class II, division 1:						
Skeletal I	Number	9	10	7	6	32
	Per cent	28	31	22	19	
Skeletal II	Number	76	113	86	55	330
	Per cent	23	34	26	17	
Skeletal III	Number		3	1		4
	Per cent		75	25		
Angle's Class II, division 2:						
Skeletal I	Number	32	48	49	23	152
	Per cent	20	32	32	16	
Skeletal II	Number	51	79	55	29	214
	Per cent	24	37	26	13	
Skeletal III	Number	2	2	3	4	11
	Per cent	18	18	28	36	
Angle's Class III:						
Skeletal III	Number	9	11	11	4	35
	Per cent	25	32	32	11	
						1468

Table II.—Tooth Sizes in Malocclusion: Incompetent Lips

Occlusion		Code M–D Width (mm.)				Total
		S (<8·5)	4 (8·5–8·99)	5 (9–9·49)	L (>9·49)	
Angle's Class I:						
Skeletal I	Number	9	11	17	14	51
	Per cent	17	22	33	28	
Skeletal II	Number		1	2		3
	Per cent		33	67		
Skeletal III	Number		3	9	4	16
	Per cent		19	56	25	
Angle's Class II, division 1:						
Skeletal I	Number	35	47	68	31	181
	Per cent	20	26	38	16	
Skeletal II	Number	60	96	76	46	278
	Per cent	22	35	27	16	
Skeletal III	Number		1	1		2
	Per cent		50	50		
Angle's Class III:						
Skeletal III	Number			1		1
	Per cent			100		
						532

sample there was only 1 individual each in Codes 0 and 9. Accordingly the data was made more comprehensible in *Tables I* and *II* and *Fig.* 6 by combining Codes 0, 1, 2, 3 as S for small (<8·50 mm.) and Codes 6, 7, 8, 9 as L for large (>9·49 mm.).

Keeping competent and incompetent lip groups apart, graphs were prepared for each malocclusion class, plotting the number of individuals against their size codes. A Gaussian distribution was apparent in every class with the peaks always fairly close to the overall mean. The percentage of each class of malocclusion in each size-range of teeth was calculated. There was a preponderance of some malocclusions (e.g., Class II, division 1 Skeletal II) in every size range because of their very high incidence in the group. Accordingly the percentage of each class of malocclusion in each size range was divided by the percentage of that class of malocclusion in the competent or incompetent lip group. The answer, multiplied by 100, was used to indicate the fraction of individuals for the given size range with respect to the number in the class of malocclusion. These fractions were used to prepare the graphs in *Figs.* 7, 8. Beside the label for each class of malocclusion the number of individuals in that class is indicated. Although not of themselves statistical evidence these groups do indicate a tendency, when allowance is made for the fact that some malocclusions are more numerous than others, for some malocclusions to occur more readily when the teeth are small and others more readily when the teeth are large.

In the competent lips group, when the teeth are large there are relatively few Class I Skeletal III, Class II, division 1 Skeletal II, and Class II, division 2 Skeletal II, malocclusions (*Fig.* 7). When the teeth are small there are relatively few Class II, division 2 Skeletal I, and Class I Skeletal I, malocclusions (*Fig.* 8).

These apparent differences were examined statistically using the figures shown in *Tables I* and *II* for the (10) malocclusion classes where the numbers exceeded 30. The mean tooth sizes, derived from the group data, were '*t*' tested to discover if they differed from the mean of the two categories combined. The only significant differences were:—

Significantly larger than the mean:

Class I Skeletal I, competent
$0{\cdot}05>P>0{\cdot}025$

Class II Skeletal I, incompetent
$0{\cdot}025>P>0{\cdot}01$

Significantly smaller than the mean:

Class II, division 2 Skeletal II
$0{\cdot}025>P>0{\cdot}01$

Table III.—Sex Differences with Large and Small Teeth

Class	Sex	Small to Average First Incisors		Larger than Average Incisors		Total
Competent:		Per cent	Number	Per cent	Number	
Cl. I, Sk. I	M.	33·5	60	66·5	119	179
Cl. I, Sk. I	F.	60·5	161	39·5	105	266
Cl. I, Sk. III	M.	54·0	46	46·0	39	85
Cl. I, Sk. III	F.	56·0	79	44·0	56	135
Cl. II, div. 1, Sk. II	M.	53·0	69	47·0	61	130
Cl. II, div. 1, Sk. II	F.	63·0	126	37·0	74	200
Cl. II, div. 2, Sk. I	M.	42·6	29	57·4	39	68
Cl. II, div. 2, Sk. I	F.	62·0	52	38·0	32	84
Cl. II, div. 2, Sk. II	M.	50·5	43	49·5	42	85
Cl. II, div. 2, Sk. II	F.	68·2	88	31·8	41	129
Incompetent:						
Cl. II, div. 1, Sk. I	M.	38·4	33	61·6	53	86
Cl. II, div. 1, Sk. I	F.	51·7	49	48·3	46	95
Cl. II, div. 1, Sk. II	M.	45·5	57	54·5	68	125
Cl. II, div. 1, Sk. II	F.	65·5	100	34·5	53	153

Sex and Malocclusion Classes

It was found in the investigation of the plaster casts that in malocclusion the teeth of males are on average larger than those of females. Accordingly it might be expected that more males than females would be found among the larger tooth range of the various malocclusion classes and this was so. In *Table III* tooth size Codes 0–4 have been combined as 'small to average'. Code 4 was for upper first incisors 8·50–8·99 mm. wide. The average width of 4000 first incisors was 8·9 mm. For 181 boys the upper first incisor averaged 8·9 mm. and for 319 girls the average

was 8·8 mm. Thus the average could be regarded as close to the upper limit of Code 4. Codes 5 to 9 were combined as ' larger than average '. There are examples where the males with larger than average teeth outnumber the females with similar teeth, despite the preponderance of females in the class. These are Class I Skeletal I, Class II, division 2 Skeletal I, and Class II, division 2 Skeletal II in the competent lips group. In the incompetent lips group the examples are Class II, division 1 Skeletal I, and Class II, division 1 Skeletal II. In the case of the other malocclusions in the table, the percentage of males with teeth larger than average is in each class greater than the percentage of females with such teeth.

SUMMARY

An investigation of tooth size among all (Angle's and Skeletal) classes of malocclusion revealed an increased number of subjects with small teeth in some and with large teeth in others. The distribution of the malocclusion classes in the sample conformed to the view that soft tissue form and behaviour in combination with skeletal morphology determine an individual's malocclusion class.

Acknowledgements

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ECTOPIC INCISORS

SOME CASE REPORTS

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FROM birth an infant passes through many stages of development; one which gives joy to the parents is baby's first steps.

The developmental progress of infants has been classified by Sheridan (1967) who describes one of the phases as follows: ' 15 months, walks unsteadily with feet wide apart and arms flexed at shoulder level to balance. Starts alone, but frequently stopped by falling or bumping into furniture '.

The deciduous upper labial segment has erupted by this stage and trauma can be transmitted via the deciduous teeth to their permanent successors. The effects depend on the time of the trauma in relation to dental development, also on the degree and direction of the force.

Mild trauma may interfere with maturation producing a constriction with a slender line of hypoplasia, and may modify the position of the tooth in the follicle and alter its path of eruption.

More severe trauma may cause dilaceration of the crown, and this disturbance of maturation may produce a more extensive area of hypoplasia.

Trauma, at a later stage of development, can cause dilaceration of the root. More severe trauma may cause complete displacement of the tooth and if dilaceration of the tooth is extensive, removal may be necessary.

INVESTIGATIONS

Case History

Children frequently fall and, unless dramatic, the traumatic incident may not be recalled by the patient or parent. Alternatively, they may agree to a history of trauma to please the clinician or to terminate the inquiry.

Inspection

Visual examination may reveal a discolored deciduous tooth, but these may be avulsed by the trauma to leave an edentulous space. Retraction of the upper lip may reveal the displaced tooth under the mucosa, the incisal edge palpable high in the labial sulcus with the apex palpable on the palate.

Radiographic Investigation

If the tooth is not palpable, its presence can be confirmed by an intra-oral or occlusal radiograph. These views also provide information about the position of the displaced tooth, its root morphology, and possibly about the condition of the pulp.

If facilities for a lateral skull view are not available, then the lateral maxilla or profile view provides diagnostic information of clinical value. For a satisfactory view, the use of a cassette with intensifying screens is essential, though there is loss of soft-tissue outline if a wedge filter is not used.

Space Available

The younger the patient, the better the prospect of bringing the tooth into line, before forward movement of buccal segments causes space-loss. Older patients can be treated but where space-loss has occurred, extraction of premolars is usually necessary.

TREATMENT

The surgical procedure is not difficult and depends on the decision to retain or remove the ectopic tooth. Exposure carried out under general anaesthetic is kinder to the young patient and, as the head is steady, reduces the risk of establishing an oronasal fistula or causing damage to adjacent structures.

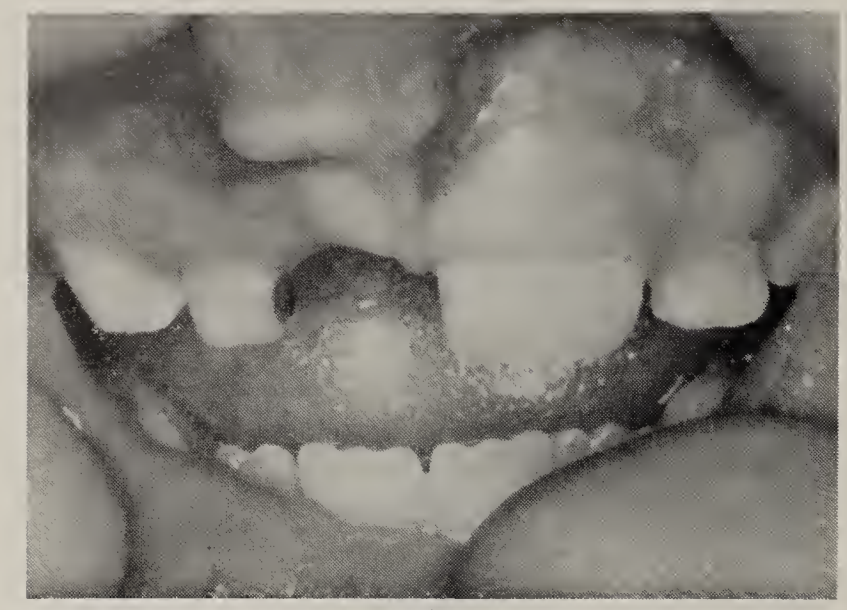
If the tooth is deep in bone, it may be necessary to fit a preformed band or cap to encourage eruption. The wound may be kept patent by the use of a zinc-oxide pack. Following pack removal, the eruption can be kept under observation until the tooth can be positioned by appliance therapy.

CASE REPORTS

Case 1

This patient was a 7-year-old girl who insisted that the mother should bring her for treatment and complained of failure of eruption of the upper right central incisor. Retraction of the upper lip revealed the displaced tooth under the mucosa (*Fig.* 1A). The

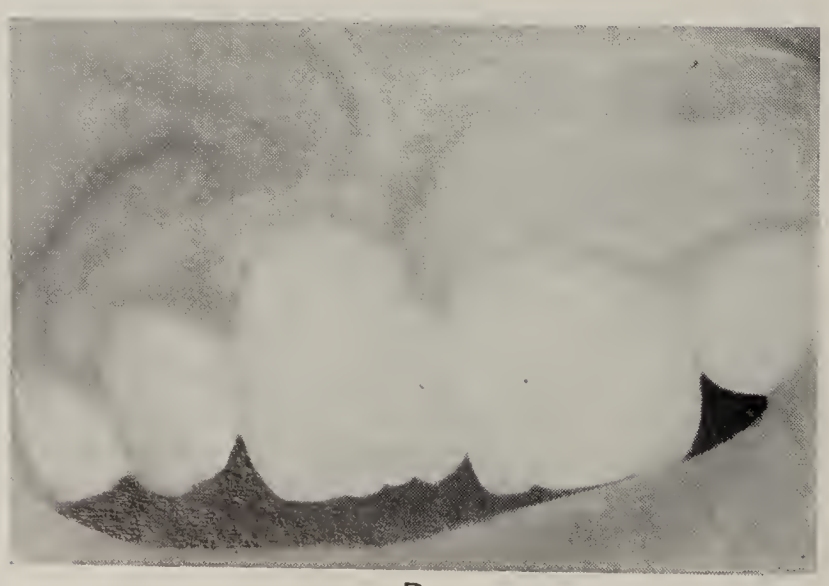
Presented at the Country Meeting held in Leeds on 11 April, 1969.



A

B

C



D

Fig. 1.—*Case* 1. A, The upper right central incisor is visible under the mucosa and upper labial fraenum. B, The occlusal radiograph shows an open apex and straight roots. C, The lateral skull radiograph and tracing. D, The upper right central incisor has been over-retracted, whilst there is slight apical displacement of the gingival margin; contour is good.

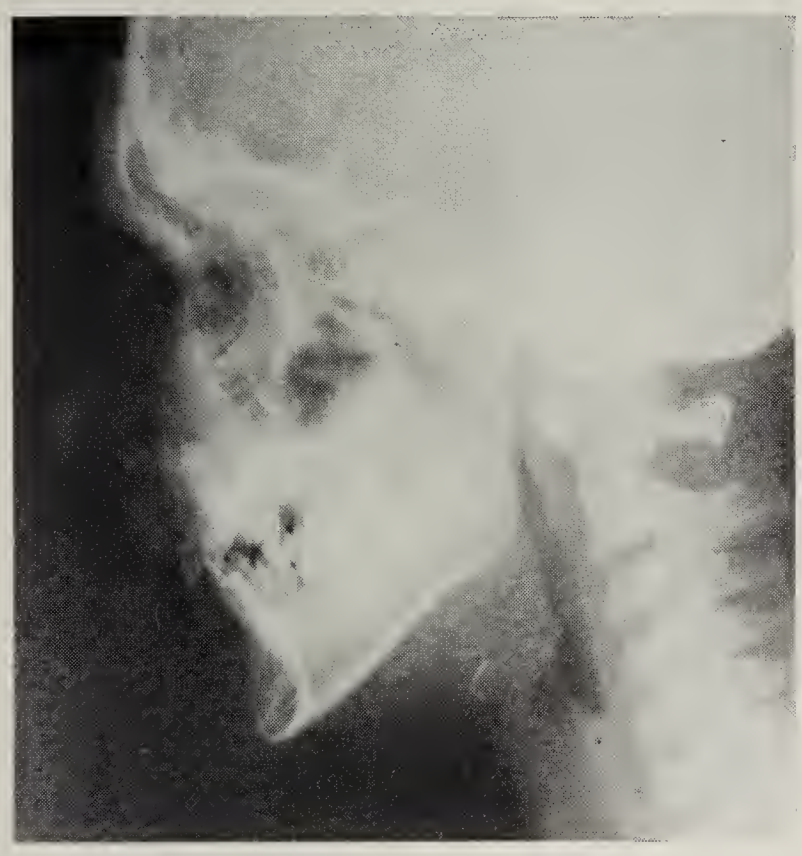
incisal edge was palpable high in the labial sulcus and the root apex palpable in the palate. The occusal radiograph (*Fig.* 1B) confirmed the presence of the tooth and while the apex was still open, the root was straight. The lateral skull radiograph and tracing (*Fig.* 1C) confirmed proclination of the upper right central incisor at 168° to the maxillary plane and its fully erupted neighbour at 105° to the maxillary plane. The tooth was exposed under general anaesthetic, no bone was removed, and patency of the incision maintained by the use of a zinc-oxide pack, which was removed 10 days postoperatively. Eruption of the tooth was observed for a period of 6 months, then a removable appliance with a flexible labial bow was provided and retraction completed in two months.

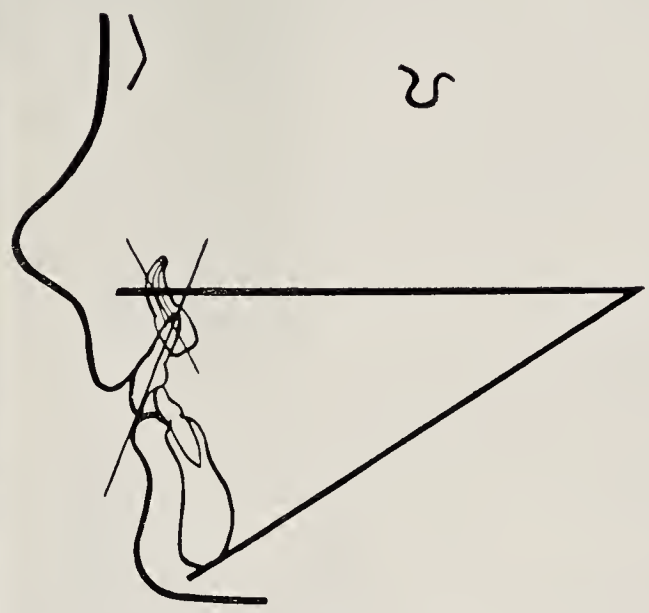
Since rotations are corrected by over-rotation, I thought over-retraction would be necessary in cases of this nature (*Fig.* 1D) but after this case I have decided that over-retraction is unnecessary.

Case 2

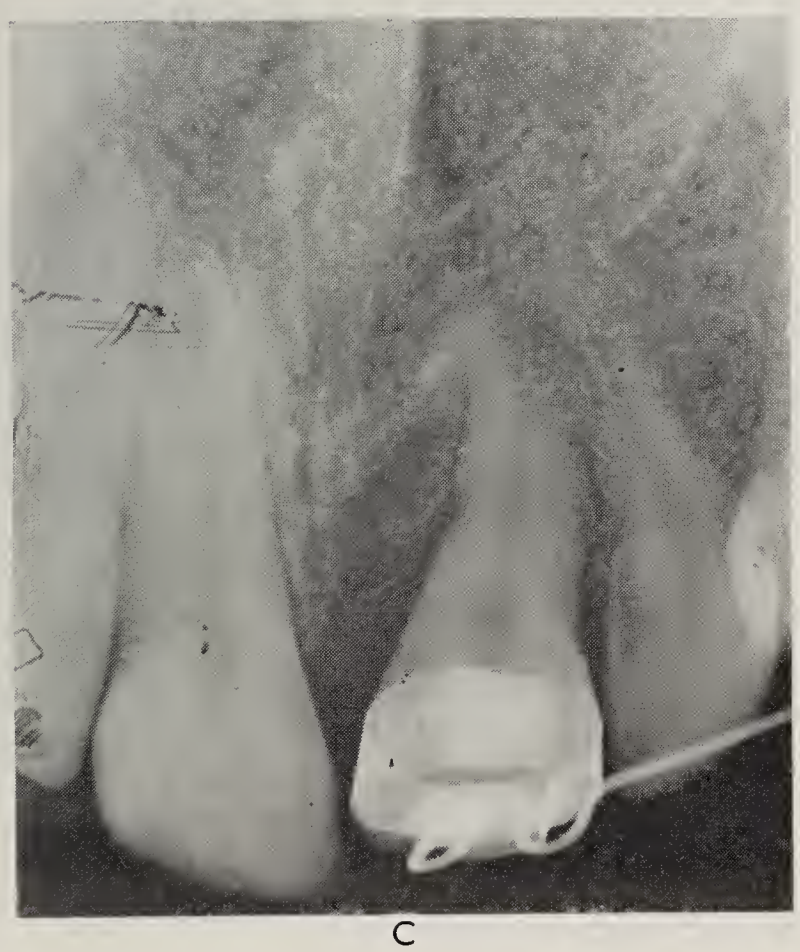
The second case was a 12-year-old boy who was referred by his general practitioner on account of failure of the left central incisor to erupt. The occlusal radiograph (*Fig.* 2A) confirmed its presence and displacement. The lateral skull radiograph and tracing (*Fig.* 2B) showed the left central incisor retroclined, rotated, and dilacerated. The tooth was exposed under a general anaesthetic; the palatally displaced canine was removed at the same operation. A removable appliance with a modified Z-spring was used to procline the central incisor for 15 months and a pin and tube appliance completed alinement in 5 months (*Fig.* 2C). When last seen (*Fig.* 2D), the final position was reasonable. The gingival margin was reasonable.

A





B



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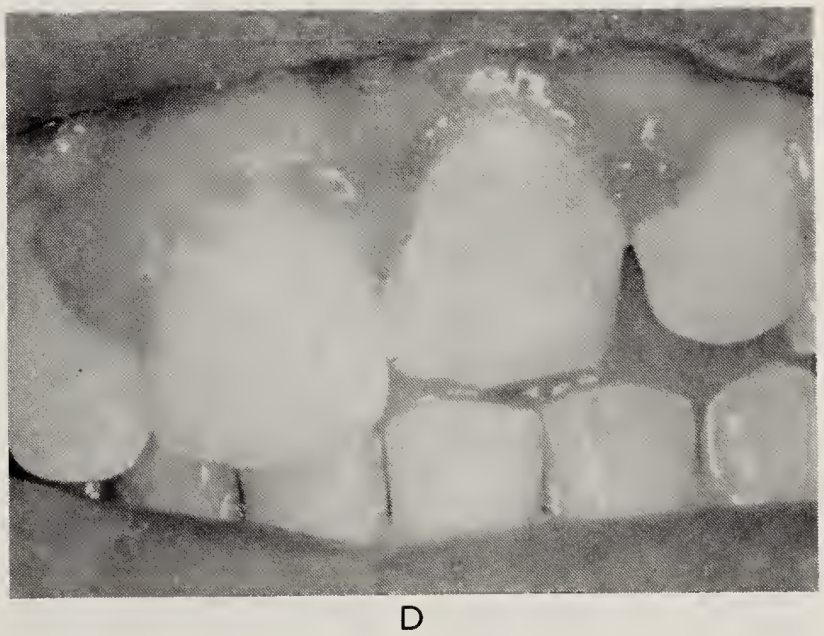

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Fig. 2.—*Case* 2. A, The occlusal view shows palatal displacement of $\underline{|1}^{3}$. B, The lateral skull radiograph and tracing demonstrate retroclination, rotation, and dilaceration of $\underline{|1}$. C, This illustrates dilaceration of $\underline{|1}^{2}$. D, When last seen there was good gingival contour; the lack of vertical development may be due to a combination of dilaceration and prolonged proclination.

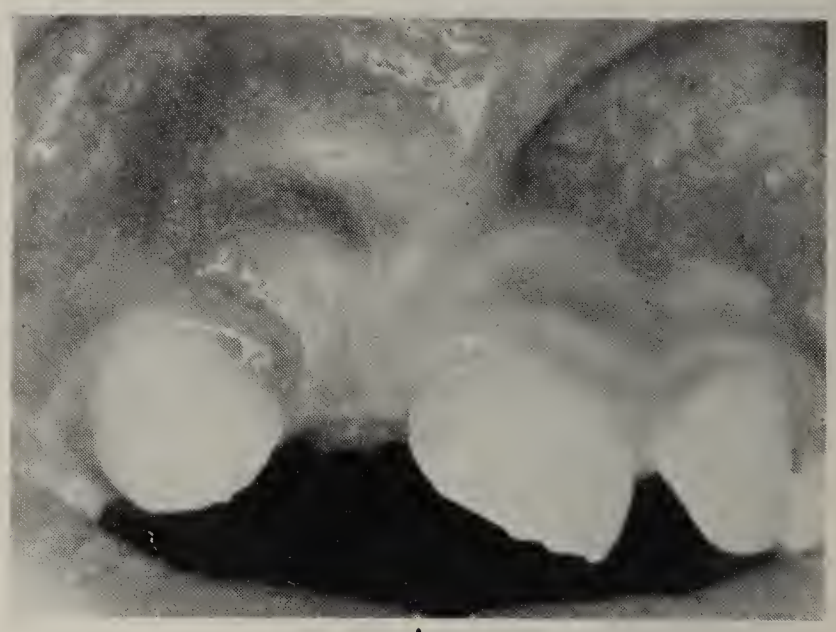
but the lack of vertical development may be due to the distance it has been proclined, or to dilaceration of the root seen in *Fig.* 2C.

Case 3

The third case was a girl first seen at 10 years with the upper right central incisor visible through the mucosa (*Fig.* 3A) with considerable space-loss, but no definite history of trauma. The lateral skull radiograph and tracing showed its proclination (*Fig.* 3B).

The tooth was exposed under a general anaesthetic and when the oral mucosa was incised, the floor of the cavity was formed by nasal mucosa; in some cases there may be a risk of establishing an oronasal fistula. A preformed band was cemented at operation and the pack removed 2 weeks later (*Fig.* 3C). A removable appliance recovered the space for the upper right, central incisor in 4 months, and a twin-wire arch brought it down in a further 4 months.

This final position (*Fig.* 3D) was quite satisfactory.



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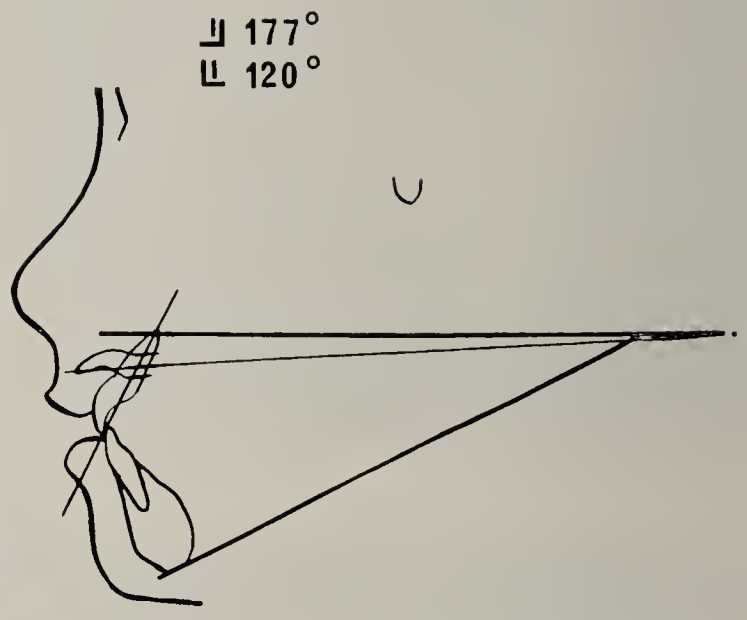

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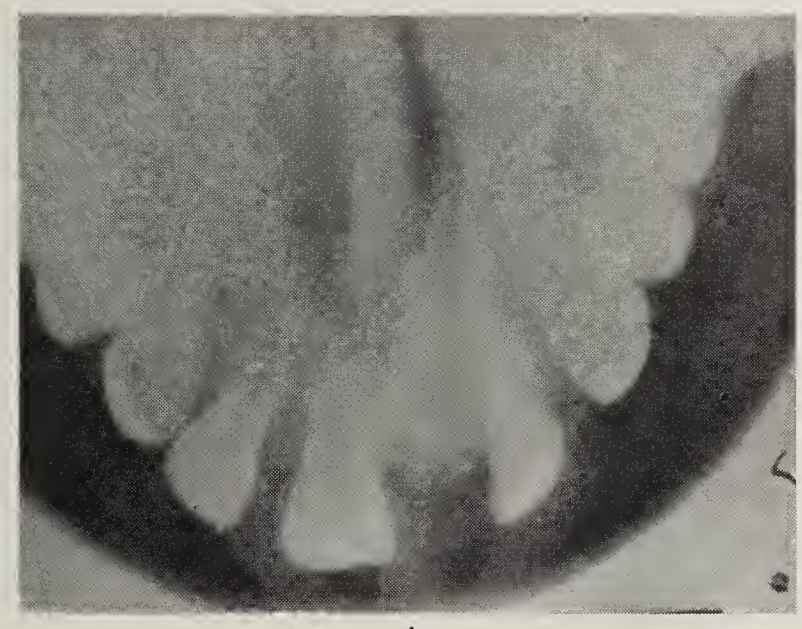
Fig. 3.—*Case* 3. A, The 1| is under the mucosa with considerable space-loss. B, The lateral skull radiograph and tracing show the extent of proclination. C, Following pack removal, an oblique profile view with axis of 1| parallel to floor was taken. D, The final view has an excellent gingival contour.

Case 4

The fourth case was a 10-year-old girl with a displaced upper left central incisor. The occlusal radiograph (*Fig.* 4A) showed displacement to the left and space-loss. The lateral skull radiograph and tracing (*Fig.* 4B) showed its proclination. The upper first premolars were extracted and the canines and incisors retracted to regain the space. The tooth was exposed under a general anaesthetic and an upper multiband appliance brought the tooth into line in 4 months. The final position was good (*Fig.* 4C), and apical displacement of the gingival margin looked better than that of the right central which erupted normally.



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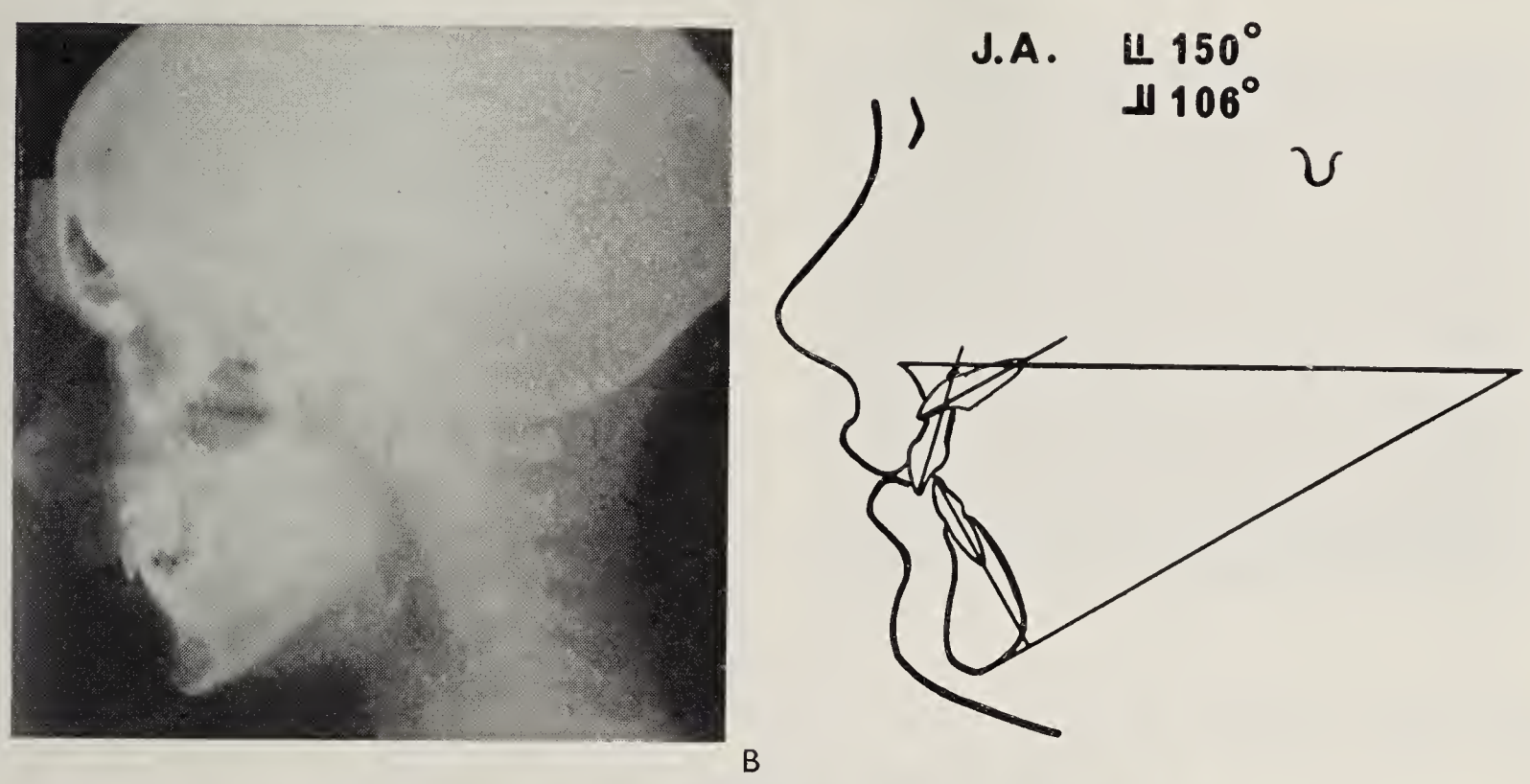


B

C

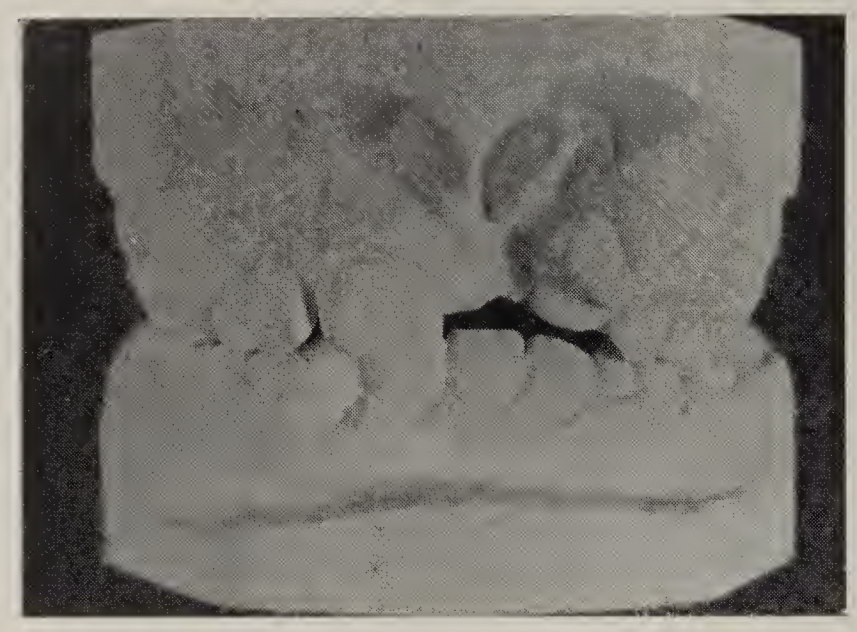
Fig. 4.—*Case* 4. A, The occlusal view shows displacement and space-loss. B, The lateral skull radiograph and tracing show the extent of proclination. C, Final view in good position with good gingival contour.

Case 5

The fifth case was a 10-year-old boy who fell when he was $2\frac{1}{2}$ years old. The early records were lost. The model (*Fig.* 5A) was taken following pack removal and shows the upper left central and lateral incisor proclined and rotated. Eruption was kept under observation for 4 months (*Fig.* 5B), then a round-wire arch with third power bends was used to bring them down over a period of $4\frac{1}{2}$ months. Then final positioning was achieved with an edgewise arch using second order bends. Before completion of treatment (*Fig.* 5C), a radiograph showed dilaceration of the roots of both central incisors and obliteration of the pulp of the left central incisor. The upper right canine was extracted.

Following band removal (*Fig.* 5D), the colour of the teeth was identical although there was slight discrepancy of gingival level.

(This patient has been seen since this paper was read to the Society and pulp testing of the upper incisors gave the following readings: $\underline{2|}$, 45; $\underline{1|1}$, 35; $\underline{|2}$, 40.)



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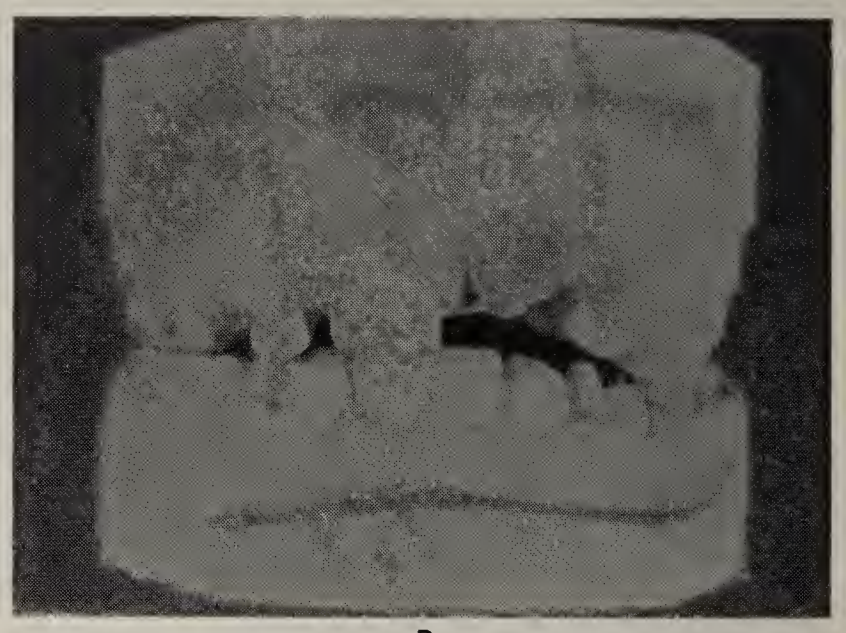

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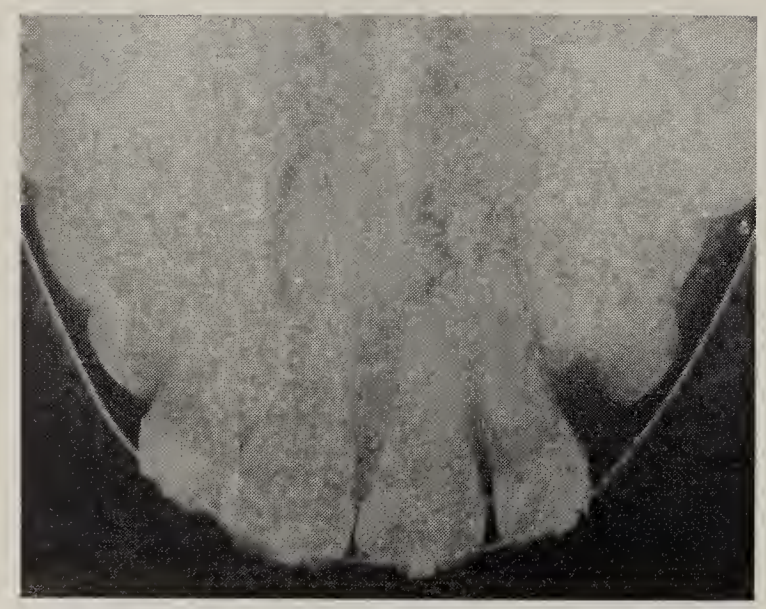

C

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Fig. 5.—*Case* 5. A, Study models following pack removal. B, Extent of eruption in 4 months; at commencement of appliance therapy. C, The roots of both central incisors are dilacerated with pulp obliteration of the left central. D, The final view.

Case 6

The sixth case was an 8-year-old girl who fell at 15 months and shattered the deciduous incisors which were removed and the gum sutured. When she attended for treatment (*Fig.* 6A), the upper left lateral incisor was the only incisor erupted but the other incisors were visible under the mucosa. The occlusal radiograph showed the roots were straight. The lateral skull radiograph and tracing (*Fig.* 6B) showed proclination of the incisors 143° to the maxillary plane. The teeth were exposed under general anaesthetic and 4 months postoperatively (*Fig.* 6C) are nearly fully erupted.

DISCUSSION

Trauma to the upper deciduous incisors may cause delayed eruption of the permanent successors necessitating surgical exposure. The trauma may cause dilaceration and, depending on its degree and direction, removal may be necessary.

When a patient attends with shattered deciduous incisors, the parents should be informed of the possible effects on the permanent successors, and of the necessity to return for assessment of incisor position when the child is 7 years old.

If dilaceration is moderate, exposure may enable ectopic teeth to erupt and final alinement

may be obtained by any of the wide range of appliances available.

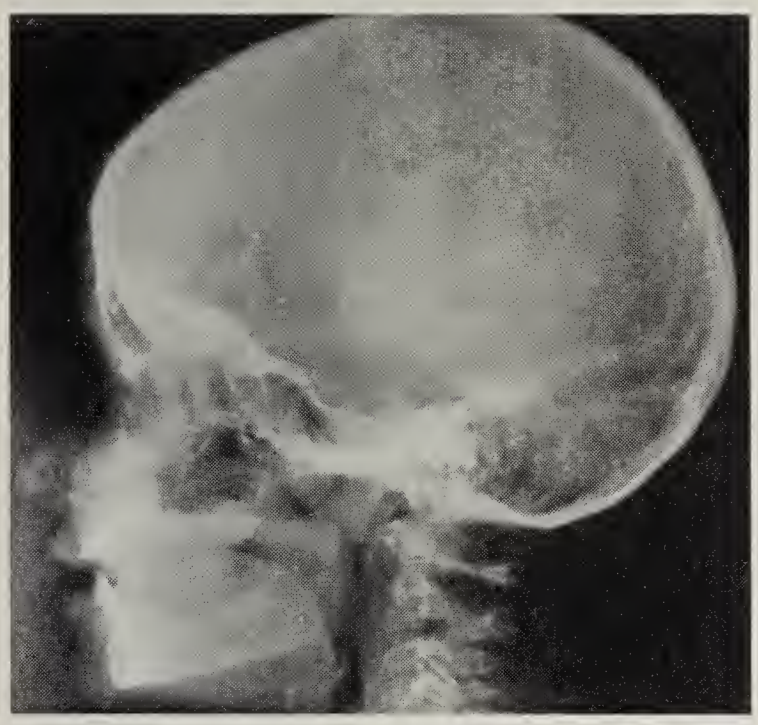
Kim (1964) used an edgewise band-up following pack removal.

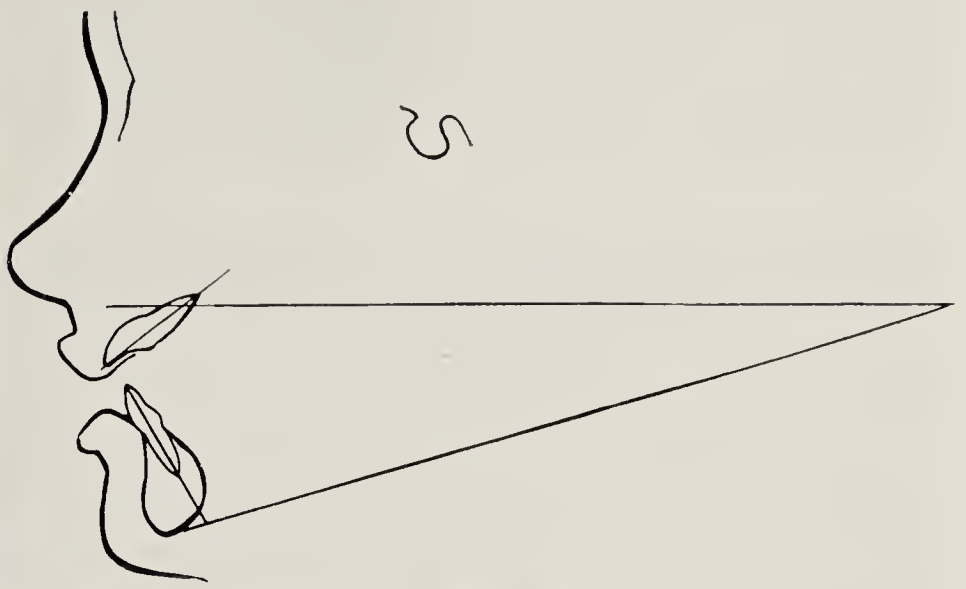
Kettle (1958) has described a technique of pinning incisors.

Cooke (1950) reports a case of a 16-year-old girl where the upper left central incisor erupted spontaneously following exposure.

Burke (1963) found the rate of eruption of exposed teeth to diminish as the occlusal plane is reached and that a discrepancy in gingival

A





B

C

Fig. 6.—*Case* 6. A, The upper left lateral incisor alone has erupted. B, The lateral skull radiograph and tracing show the proclination. C, The position 4 months following exposure.

level may be present up to 2 years after exposure, but disappears with time.

SUMMARY

Trauma to deciduous incisors may displace their permanent successors; some respond to simple exposure and erupt spontaneously. Others may require assistance with appliance therapy. Removal is necessary in some cases.

Acknowledgements

I would like to thank Dr. W. R. Burston for permission to present the first 4 cases and I am greatly indebted to Mr. B. B. J. Lovius for advice and encouragement while treating these cases. I am grateful to Mr. C. P. Briggs for the fifth case and for his advice while treating the patient. I am indebted to Mr. A. J. Walpole Day for permission to present the sixth case and for his interest. Thanks are due to Mr. J. S. Bailie, Photographic Department, Liverpool Dental Hospital; to Mr. P. J. Cheese, Miss A. B. May, and Mrs. J. R. Newcombe, Department of Clinical Illustration, Birmingham Dental Hospital, for the photographs; and to Mrs. K. Randle for secretarial assistance.

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DISCUSSION

Mr. C. D. Parker explained a personal interest in the problem since his elder son's upper incisors had failed to erupt although he was almost 9 years of age. Radiographs showed that the unerupted permanent upper central incisors were rotated and under the floor of the nose, with two supernumerary teeth present. What impressed Mr. Parker about the cases shown was the length of the clinical crown on the affected incisors. The question which passed through his mind was whether to expose his son's central incisors when the supernumeraries were removed, or wait until later. Mr. MacCauley had exposed the teeth when they were high up, and with a minimum of bone removal the alveolar crest was left intact. Would he agree that this was an important point in producing his very desirable results?

Mr. MacCauley said he was not trying to split hairs, but the cases which he had described were associated with trauma. Apart from the case in which the tooth was retroclined, the others were proclined and sitting in fibrous tissue, and no bone was removed in any of those cases. In the presence of supernumeraries, the teeth were usually intra-osseous, and bone removal was necessary. That might be associated with a high gingival margin. Burke had carried out work which showed that the teeth erupted more quickly if the apex was open.

Mr. C. D. Parker said that his son's teeth were rotated through 90°. They were mesially inclined and very similar to the cases shown by the author, although this was not typical of cases with supernumerary teeth. The management of his son's problem would appear to be the same as the cases shown by Mr. MacCauley with the exception of the need to remove the supernumerary teeth.

Mr. MacCauley replied that the earlier they were exposed, the earlier they would erupt. With regard to dilaceration, if Mr. Parker's son was 9 years old, the apex should still be open and root formation would progress.

The path of eruption of the unerupted tooth might be obstructed by the supernumerary or by unyielding fibrous periosteum. As it could not proceed in this path, it endeavoured to try a different path of eruption, and as root formation continued, dilaceration was produced.

Mr. D. T. Hartley said that he was impressed by the final upright position of the central incisors in the cases shown, because, although presumably the appliance could produce only a tilting movement, the original radiographs showed that in at least one case the apical part of the root was more palatally placed than that of the adjacent normal central incisor.

Regarding the lateral maxilla radiograph, he thought that provided one could standardize the relation of the X-ray tube, the patient's head, and the cassette, with the central ray passing through the incisor area, in principle this should give a more accurate representation of incisor angulation than the standard cephalometric projection centred on the auditory meatuses.

Mr. MacCauley said that, following exposure, the teeth were left to allow pressure of the upper lip to guide eruption and cause a certain amount of uprighting, so that nature achieved the most improvement and the final alinement was achieved with appliances, The simpler the appliance, the better.

Mr. T. Jason Wood asked, in the last case, where the centrals were quite straight, why didn't they erupt? Was there anything special about the tissue?

Mr. MacCauley replied that the tissue in that area, on retraction of the upper lip, appeared to be very mobile and unattached, and on section a dense layer of fibrous tissue. It was similar to the mucosa overlying a labial canine which fails to erupt.

Mr. W. Frankland said that trauma seemed to be the obvious reason for the anomalies, but was it necessarily so? It was all too easy to get a history of trauma from a parent. One had to be careful before making an assumption of trauma.

Mr. MacCauley replied that he had carefully avoided mentioning trauma if a definite history of trauma was not available. In the fifth case where the early record had been lost, the child had fallen down the stairs, and this was 'a reasonable history of trauma'.

TREATMENT OF CENTRAL INCISORS: TWO CASE REPORTS

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THE two cases which are reported in this communication are different in concept and treatment. However, they are complementary in as much as the second case shows what would have been a possible alternative treatment for the first case, if the original objective for the latter had not been achieved. Because of the doubtful prognosis for the result of the first case, alternative possibilities always had to be kept in mind. The one thing that both cases have in common

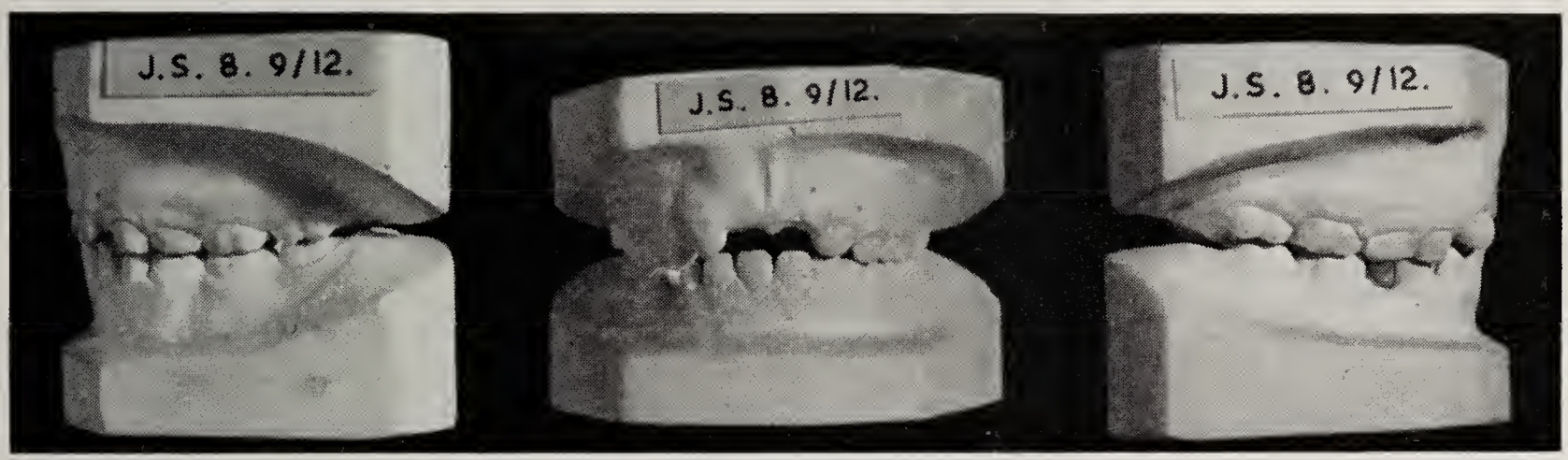

Fig. 1.—A, Before treatment. B, Prior to insertion of final appliance. At this stage no apparatus had been worn for two years. C, At completion of treatment.

Presented at the Country Meeting held in Leeds on 11 April, 1969.

is the relatively simple appliance therapy used for each of them.

TREATMENT OF INVERTED UNERUPTED CENTRAL INCISORS

Case 1

On 31 December, 1963, a girl, J.S., aged 8 years 9 months was referred by her general dental practitioner because of her unerupted upper central incisors.

On examination she was found to have a basically Angle Class I occlusion, with a normal skeletal pattern. The lips were incompetent. $\overline{d}|$ had been prematurely lost and $\underline{2|2}$ had tilted a little mesially. Apart from the unerupted upper central incisors there was no other dental abnormality present (*Fig.* 1). The incisal edges of the central incisors were palpable high in the labial sulcus. There was a history of a fall down the stairs at about 3 years old when $\underline{a|a}$ were damaged. These teeth were eventually shed normally. There was no relevant medical history.

Radiographs showed $\underline{1|1}$ to be present (*Fig.* 2A). In the lateral view $\underline{|1}$ is shown to be pointing in a near vertical direction with its incisal edge just below the floor of the nose. $\underline{1|}$ was a little less vertical. The palatal surfaces of both incisors were facing forwards and each apex was recurved upwards.

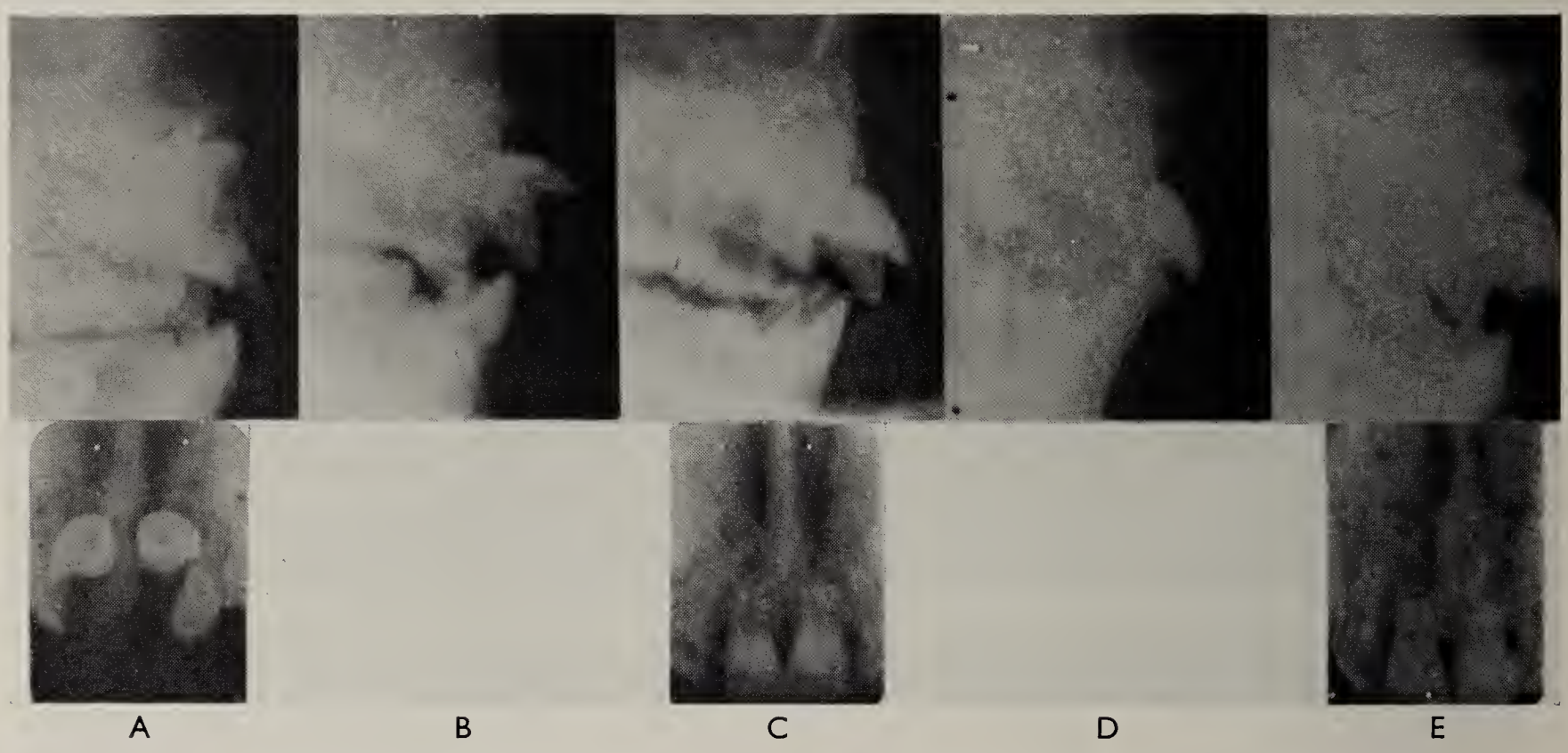

Fig. 2.—*Case* 1. X-rays showing progress of $\underline{1|1}$ as they descend into alinement. Note recurved root apices. A, Before treatment, aged 8 years 9 months. B, Five months after surgical exposure of $\underline{1|1}$. No active treatment of $\underline{1|1}$. Aged 9 years 6 months. C, Aged 10 years 2 months. D, Two months after the second appliance was discarded. Aged 10 years 10 months. E, Two months after completion of treatment. Aged 13 years 10 months. Note position of apices of $\underline{1|1}$.

Fig. 3.—*Case* 1. Models showing progress of $\underline{1|1}$ as they descended into alinement. (Compare with *Fig.* 2.)

In spite of the apparently poor prognosis, a treatment plan was formulated to attempt to bring the central incisors into the arch. The parents of the patient were aware of the risk of failure but were agreeable to an attempt being made. The initial plan was to move $\underline{2|2}$ distally. In order to have more than sufficient space for the central incisors, $\underline{c|c}$ were to be extracted at the same time as $\underline{1|1}$ were surgically exposed. Subsequently, treatment was to be reviewed in the light of progress.

A removable appliance with finger springs to retract $\underline{2|2}$ was inserted in February, 1964. Two months later the patient was admitted to the London Hospital where $\underline{1|1}$ were surgically exposed and $\underline{c|c}$ were extracted. At the time of operation a wax impression was taken of the exposed incisal edges and palatal surfaces of the central incisors and this was extended downwards to be joined onto the base plate of the existing appliance. Subsequently the wax ' bung ' was processed into acrylic to form a continuous unit with the appliance which continued to retract $\underline{2|2}$. At approximately monthly intervals the ' bung ' was progressively reduced as $\underline{1|1}$ descended. Seven months after the operation (November, 1964) a new appliance with a 0·3-mm. self-straightening wire, freely sliding at both ends, attached to a passive labial arch was inserted. (*Fig.* 4). The effect of this was to exert a gentle downward pressure on the central incisors until they reached a horizontal position. At a later stage (March, 1965) the U-loops of the labial arch were opened to raise it so that the wire rested lightly on the labial surfaces of $\underline{1|1}$. This then acted as a guide to encourage the descent of the central incisors. In November, 1965 the appliance was discarded. At this stage the position of the incisors was as shown in *Fig.* 3 (*lower left*).

The patient was then kept under observation without any treatment until November, 1967, when all the deciduous teeth had been shed and the premolars had erupted (*Fig.* 1B). A new removable appliance was then fitted, with finger springs to move $\underline{43|34}$ distally. Subsequently the labial arch was adjusted to finally aline $\underline{21|12}$. It was worn full time till September, 1968 and then at night only for 6 weeks, before being discarded. At that time the patient was 13 years 7 months old and the occlusion was as illustrated in *Fig.* 1C. A full face photograph, together with a close-up view of her teeth, is shown in *Fig.* 5. The teeth are of normal colour and give a positive response to the electrical pulp tester, though the response of the central incisors is of a lower order than that of the lateral incisors. Serial radiographs taken before, during, and at the completion of treatment are shown in *Fig.* 2. Comparative progress models are shown in *Fig.* 3. It is interesting to note that $\underline{1|}$ has rotated through an angle of 116° and that its crown has descended 2·6 cm.

Fig. 4.—*Case* 1. Appliance with 0·3-mm. self-straightening wire.

Fig. 5.—*Case* 1. Full face and close-up photographs 3 months after completion of treatment.

Fig. 6.—*Case* 2. Models showing progress of $\underline{2|2}$ as they approximated: *upper left*, before treatment; *upper right*, before active treatment. Note minimal tilting of $\underline{32|23}$. Space between $\underline{2|2}$ had reduced from 14 mm. to 5 mm. during 2 years 1 month; *lower left*, after active approximation of $\underline{2|2}$ which are ready to receive jacket crowns; *lower right*, crowns shown on $\underline{2|2}$.

TREATMENT FOLLOWING TRAUMATIC LOSS OF UPPER CENTRAL INCISORS

Case 2

In October, 1961, V.H., a girl aged 9 years 10 months, presented at the London Hospital with $\underline{1|1}$ fractured and mobile following an injury in the school playground. The Paedodontic Department considered that the prognosis was too poor to attempt to conserve the central incisors which were therefore extracted on 6 October, 1961, together with $\underline{|cde}$. One month later $\underline{dc|}$ were extracted.

At the original examination the patient was found to have a basically Angle Class I occlusion on a mild skeletal Class II dental base. There was a mild degree of maxillary crowding. The mouth was not particularly well cared for (*Fig.* 6, *upper left*).

The problem was simply whether to insert a partial denture to maintain the central incisor spaces, or, alternatively, whether to attempt to approximate the lateral incisors which could subsequently be crowned to resemble central incisors. In view of the mild maxillary crowding, it was agreed to take the second alternative.

However, it was decided to delay treatment until the mouth was put into satisfactory order from a conservation point of view, and the patient was kept under observation whilst this was being done. It was noted that the lateral incisors together with the upper buccal segments, were migrating mesially with minimal tilting (*Fig.* 6, *upper right*). This process continued until the patient was just over 12 years old. At this time, in conjunction with the Conservation Department of the London Hospital, it was thought that active approximation of $\underline{2|2}$ should be commenced and that these teeth could be stabilized with acrylic jacket crowns.

Fig. 7.—*Case* 2. ' M ' type spring to approximate $\underline{2|2}$

In January, 1965 an ' M ' type spring, attached to bands on $\underline{2|2}$, was fitted (*Fig.* 7). Four months later the lateral incisors were in suitable positions to receive jacket crowns. They were retained till October, 1965, when the crowns were constructed (*Fig.* 6, *lower*

A B

Fig. 8.—*Case* 2. Close up photograph to show: A, Immediately following construction of acrylic jacket crowns. B, 3 years 4 months later. Note marginal gingivitis associated with poor oral hygiene.

right). The patient was recalled in February, 1969, when the condition was found to be stable and satisfactory (*Fig.* 8).

It is interesting to note in this case the relatively vertical natural mesial movement of $\underline{32|23}$ and the maintained integrity of the buccal segments, which appear to have travelled forward as integral units. Active appliance therapy lasted only 4 months.

Acknowledgements

I should like to express my appreciation to Professor G. R. Seward for undertaking the surgery in *Case* 1, and to Mr. M. A. Jenkins for constructing the jacket crowns in *Case* 2. My thanks are also due to Mr. P. V. Jacobs of the London Hospital for preparing illustrations.

DISCUSSION

Mr. C. D. Parker said that he had always been taught to believe that the movement of teeth with dilacerated roots had a poor prognosis. Would the author give his experiences with repositioning other teeth with dilacerations of the root because Mr. Rose's findings were contrary to his own beliefs at the moment?

Mr. Rose agreed that dilacerations were usually not like that particular tooth, and from the clinical point of view he ignored them. From the practical end result it did not seem to make any difference whether or not dilaceration was present. One was getting reactions to pressure and tension which produced bony resorption and deposition. It did not matter where the apex was. There was no reason why there should be any ill effect, so long as one was putting the pressure on the tooth within the so-called 'physiological limits'.

Mr. J. Kurer asked whether any force had been applied to make the tooth move.

Mr. Rose replied that no force was applied until the teeth were just short of the horizontal position. At that stage he had inserted the appliance with the vertical self-straightening wire. A gentle force was applied at a period of 8 months after the surgical exposure. It might not have been necessary to put the appliance on at that time, possibly if he had been patient the central incisors would have come down on their own. Mr. Rose said he wanted to emphasize the point about the mucoperiosteal fold. If the incisors had been under that, they would have been locked.

Miss J. P. Murray asked whether the author had implied that, had the first case failed, he would have treated it similarly to the second case, in approximating laterals. There did not appear to be any crowding in that case however.

Mr. Rose said it was always difficult to say what one would have done. In his opinion the crowding in the first case was very mild, although it may not have looked so on the models. His tendency would have been in terms of maintaining the space, and putting in some kind of artificial replacement.

Mr. B. B. J. Lovius asked whether any resorption of the apices of the dilacerated teeth had taken place, especially as they were pushed against the periosteum. His second point was in regard to the eruption of dilacerated teeth. They obviously did erupt in many cases. This, therefore, threw some doubts on the validity of theories of tooth eruption, such as those depending on root formation.

Mr. Rose believed that there was some resorption. He thought that the apices on the right hand side of the last X-ray appeared to be wider than those on the earlier film. The theories of eruption were legion. He did not know the mechanism of eruption.

Mr. L. H. Russell asked about the last case. Did the conservation people specify that Mr. Rose was only to move the tooth to a certain degree, and then proceed to put their crown on? One could have predicted stagnation, the off-centre crown was asking for trouble. The point about that type of movement of laterals into a central space was that unless they were moved bodily and upright, a pocket was formed.

Mr. Rose said they were upright when they were crowned. He had been the 'technician' at the time and he had asked the Conservation Department where they wanted the teeth prior to crowns being placed. The problem of stagnation was always a relevant point if a crown was put on a smaller unit. There would be a reasonable gingival condition on the distal side but not a very good one on the mesial side.

FORCES INVOLVED IN INCISOR RETRACTION

T P. BASS, B.D.S., F.D.S., D.Orth. R.C.S.

S. I. M. ROBINSON, F.D.S., D.Orth. R.C.S.

Guy's Hospital Dental School

SEVERAL alternative methods of retracting upper incisors with removable appliances are available to the orthodontist. Their merits and demerits have been discussed by Walther (1966) and others, but no assessment of their relative effectiveness has yet been made.

The purpose of this demonstration was to compare the flexibility of eight different incisor retractors (*Table I*) when subjected to similar loadings.

The appliances were all constructed by an experienced technician on the same model. This was of a typical Angle Class II, division 1 case at the end of the first stage of treatment. The canines had been fully retracted and some incisor spacing had occurred. Each appliance consisted

Fig. 1.—' Apron ' retractor activated by fine-wire springs.

Fig. 2.—Retractor with helical coils in buccal sulcus.

Table I.—INCISOR RETRACTORS TESTED FOR FLEXIBILITY

No.	DESCRIPTION	WIRE SIZE (mm.)	REFERENCE
1	Split labial bow	0·7	Tulley and Campbell, 1965
2	High labial bow carrying apron activated by auxiliary springs	0·9 0·7 0·35	Walther, 1966 (*Fig.* 1)
3	High labial bow carrying apron spring	0·9 0·35	Adams, 1964
4	Roberts retractor	0·5	Dickson, 1964
5	Mills retractor	0·7	Mills, 1956
6	Retractor with coils in sulcus	0·7	Walther, 1966 (*Fig.* 2)
7	Conventional low labial bow with reverse loops	0·7	—
8	Conventional low labial bow with U-loops	0·7	—

Demonstration at the Country Meeting held in Leeds on 11 April, 1969.

of the incisor retractor carried on a cold-cure acrylic resin baseplate, which was extended distally as a flat flange through which two holes were drilled to take short machine screws (*Fig.* 3).

To enhance accuracy of measurement a device was constructed to magnify the movement occurring at the centre of the incisor retractor by a factor of 10 (*Fig.* 4). Each appliance was then bolted in place as shown in *Fig.* 4 and the incisor retractor connected to the swinging arm by a length of 0·6-mm. wire. The lead counterbalance weight has been previously adjusted until the arm balanced. The scale reading was then noted to the nearest 0·5 mm. and the retractor was progressively extended by placing weights in the pan. In this way a load/deflexion table was prepared for each appliance.

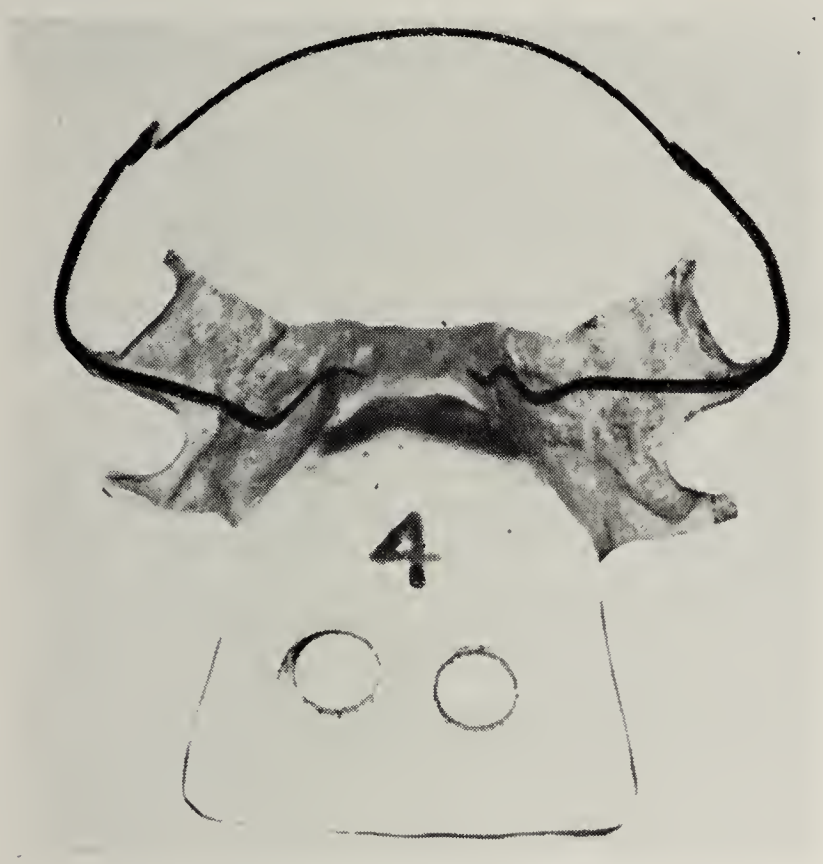

Fig. 3.—Typical test appliance.

The graph shown in *Fig.* 5 is derived from the load/deflexion tables. Mean figures were taken from five tables prepared for each appliance.

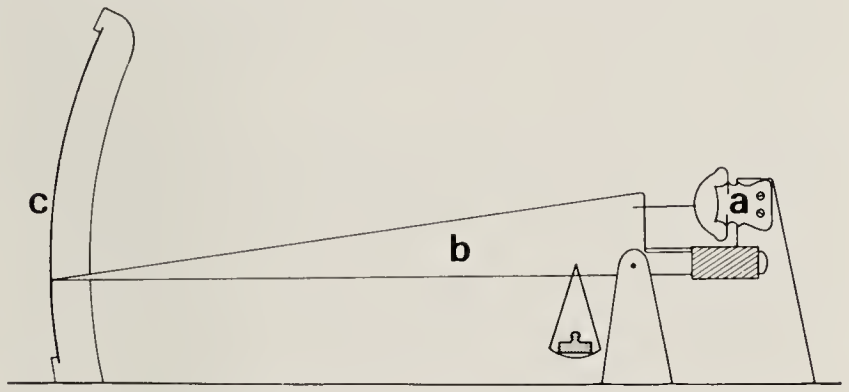

Fig. 4.—Apparatus used for measuring deflexion showing: (a) appliance, (b) swinging arm with pointer and counterbalance weight and (c) scale (engineer's rule).

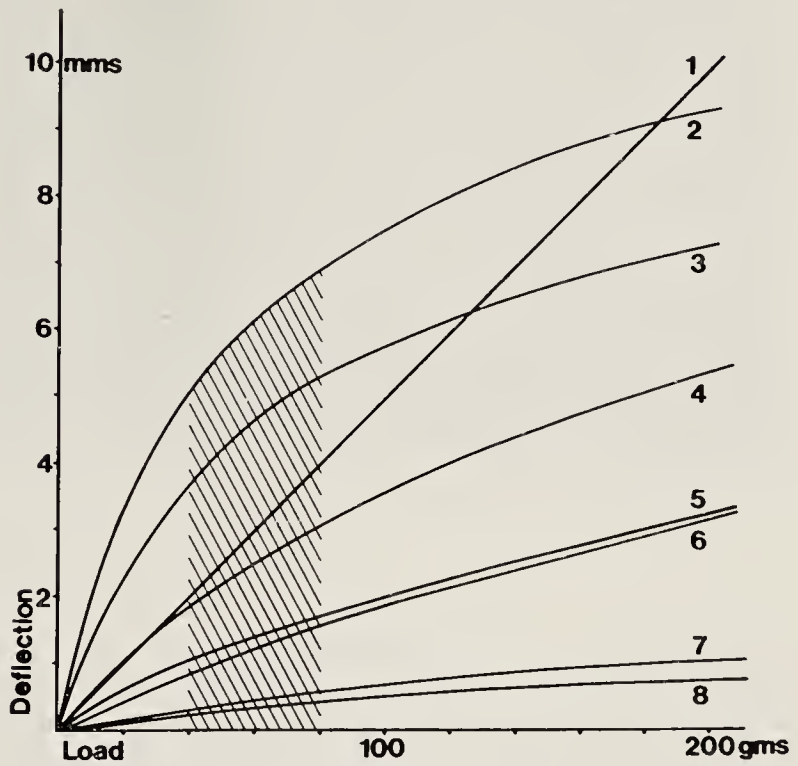

Fig. 5.—Load/deflexion curves for the eight appliances.

DISCUSSION

While the curves shown in *Fig.* 5 refer to one case only, they provide helpful comparative data for the different types of retractor. Naturally, alternative series of readings would be obtained from appliances constructed on other models. One would also expect the flexibility of the retractors to vary a little depending on their absolute size and the details of their construction.

However, the general trend is clear, the differences between the four types of retractor being too large to be much influenced by their size and minor variations in their construction.

Firstly should be noted the extremely large forces that can be applied to incisors by the injudicious activation of the simple labial bow. The difference between the U-loop bow and the reverse-loop bow is negligible in this context. An activation of 1 mm. can apply a force approaching 200 g., well outside the 20–25 g. per single-rooted tooth recommended in the literature (Tulley and Campbell, 1965). It is evident that the use of these as active retractors is inefficient in the reduction of any but the mildest of incisor overjets.

The other two retractors made from 0·7-mm. wire (Nos. 5 and 6) show increased flexibility by comparison with the simple labial bows in the required 40–80 g. range; approximately 1·5 mm. of activation appears to apply a force at this level.

It is apparent, however, that the fine-wire retractors (Nos. 2, 3, and 4) provide a degree of flexibility most appropriate in the reduction of gross overjet. The Roberts retractor (No. 4) with its fine wire supported within and therefore stiffened by tubing, is, as expected, the least flexible of the three. Play where the heavy apron (No. 2) is wound around the high labial bow and the ability of the lower ends of the activating

springs to move freely up and down the vertical bars of the apron, appear to account for the greater flexibility afforded by this retractor compared with the more conventional apron spring (No. 3). It is, however, appreciably more difficult to construct. The increased flexibility of the three fine-wire retractors is achieved at the expense of vulnerability. The fine wires are always prone to fracture and distortion so they are best reserved for the careful and co-operative patient.

The split labial bow (No. 1) provides the greatest flexibility at the limit of the loadings chosen, but in the desired 40–80 g. area is inferior to the two apron retractors and comparable with the Roberts appliance. The flexibility is produced mainly by distortion of the wire where it emerges from the acrylic, which probably accounts for the linear relationship between load and deflexion shown by this retractor only. In all other cases, the flexibility results mainly from the distortion of wire within the retractor. The flattening of the curves is most noticeable for the two apron retractors above the 80-g. loading; as the apron is extended its flexibility decreases because its vertical arms approach more nearly to the direction of application of the load.

Acknowledgements

We are grateful for the assistance of Mr. P. Chittenden who constructed the eight appliances and helped with the design and manufacture of the deflectometer. Miss J. Hodgkin of the Dental Photographic Unit, Guy's Hospital, took the photographs of the appliances.

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USES OF THE WATKIN APPLIANCE

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THE appliance which forms the subject of this paper was evolved by the late H. G. Watkin, and was originally called the ' pin and tube '. From this one assumes that the idea came from the appliance of the same name introduced by Angle (1912), but the resemblance between the two is so slight that Watkin's must be considered as a different appliance. Towards the end of his long life, he changed the name to the ' loop and tube ', but, while this is probably a better name, the older one dies hard. It was first described in the originator's Presidential Address to this Society in 1933, and various aspects of its use have been published since that date by P. A. Watkin (1951), Watkin, Watkin, Clifford, and Murray (1958), Leighton (1963), Clifford (1965), and Mills (1967).

I was introduced to the appliance by Mr. Watkin when working as an assistant in his practice in 1944. Since then it has doubtless been modified to some extent in my hands, both consciously and unconsciously, so that the techniques which I shall describe here are those which I personally employ; while making no claim for originality I take full responsibility for their shortcomings.

The appliance involves the use of bands on a limited number of teeth: the teeth to be moved and usually a small number of anchor teeth. The novel feature lies in the method of attachment of the archwire to the bands on the teeth to be moved. The band concerned carries a vertical rectangular tube, based on the female part of the McKeag lock, and shown in *Fig.* 1. This should preferably have two short vertical slits running up its labial surface from the gingival edge as on $\underline{1}|$. The wire is bent into the shape of the letter U, so that this U-shaped piece of wire, which forms the ' pin ', is a rather slack fit in the vertical tube, with its end protruding therefrom. If no further bends were incorporated, the archwire would lie uncomfortably close to the occlusal surface of the teeth, and a further bend is therefore added so as to bring the horizontal part of the wire closer to the gingival margin, as shown distally to $\underline{1}|$. The pin may be retained in the tube, as shown on $\underline{1}|$ by depressing the tongue of tape between the two slits in the tube. Alternatively, if the pin lies at the end of the archwire, the extreme end may be bent round, as shown on $|\underline{1}|$, so as to latch into the protruding end of the pin, preventing its withdrawal. A further method of retaining the pin in the tube by means of a ligature will be described later. This forms (apart from the slight ' play ' due to the loose fit of the pin in the tube) a completely rigid attachment between band and archwire, and makes possible

Fig. 1.—Pin and tube attachment of the Watkin appliance, showing two methods of retaining the ' pin ' in the ' tube '.

movement of either the crown or root of the tooth in any desired direction. Like any such appliance it is potentially dangerous, and it is most important that after any adjustment, the wire should be carefully checked to make sure that unwanted activations have not been introduced.

Watkin himself used the appliance for a wide range of tooth movements. I personally confine its use to those described below.

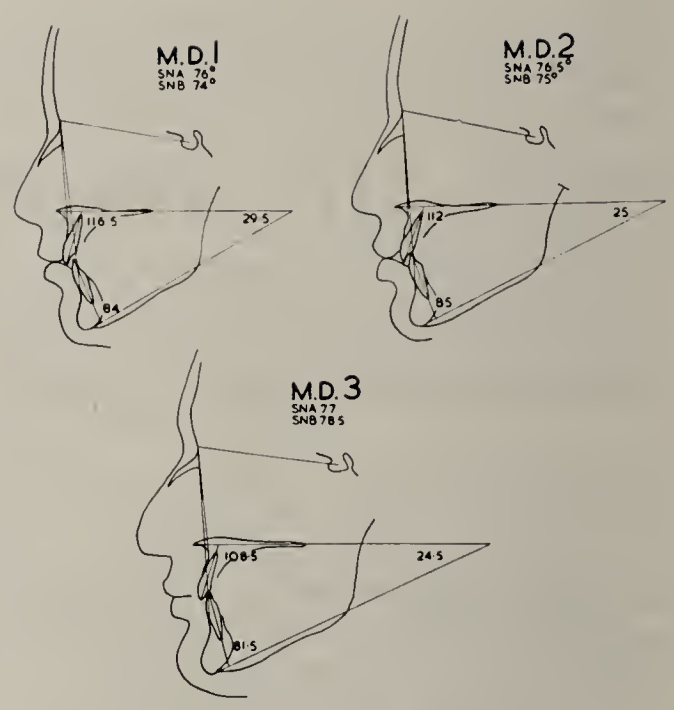
THE ROTATION OF INDIVIDUAL TEETH

Case 1

Michael (*Fig.* 2 A) was first seen in August, 1958, at the age of 10 years, 10 months. He had well-alined incisors, in good relation to each other, apart from $\underline{1}|$, which was rotated through 90°, mesiolingually (*Fig.* 2 B). There was no obvious reason for this rotation, and no relevant history. There was adequate room for it in the arch, and radiographic examination revealed no abnormality of the root. The first molars had moved forward, following early loss of deciduous

Presented at the Country Meeting held in Leeds on 11 April, 1969.

A



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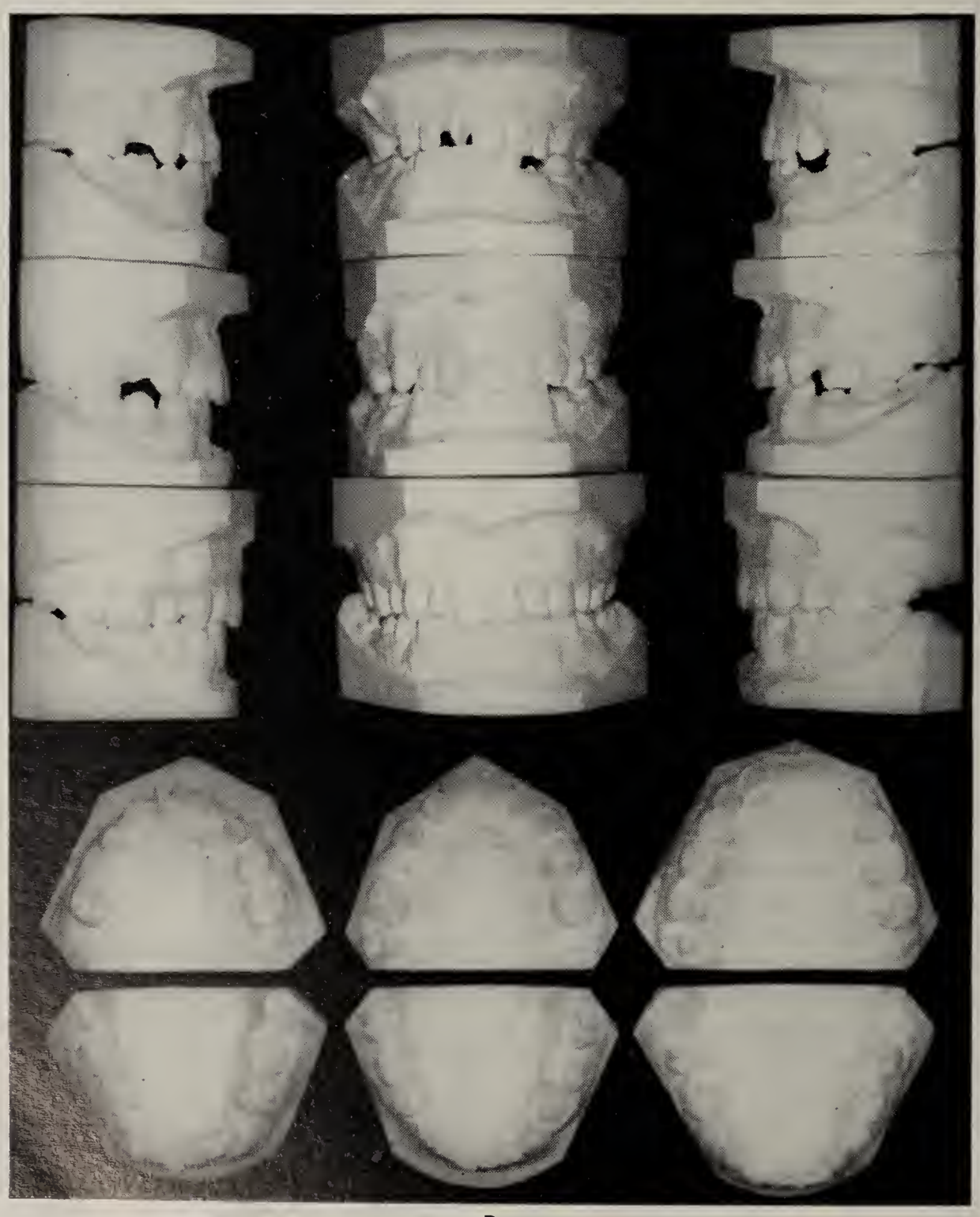


B

Fig. 2.—Records of *Case* 1. A, Photographs; B, Models, before treatment, at the end of treatment, and 5 years 1 month out of retention; C, Tracings of radiographs taken at same time as the models.

molars, and there was a lack of space for premolars and canines.

Since the incisor position seemed traumatic, it was decided to correct 1| without delay, and this was carried out successfully, using the appliances described below, between September, 1958, and August, 1959, slight over-rotation being achieved.

Four first premolars were extracted and, in addition, because of the severity of the crowding, 6|6 were moved distally by means of extra-oral traction applied through a Kloehn bow to bands on 6|6. During this period the incisor was retained by means of a fixed sectional arch on 1|1. Thereafter, an upper removable space maintainer was worn nocturnally until the canines and second premolars were in position, and this also served to retain the rotated incisor. The tooth was therefore retained for the quite exceptional time of 2 years 3 months. Despite this lengthy retention and slight over-correction, very slight relapse took place. The final records were taken 5 years 1 month out of retention (*Fig.* 2 B, C).

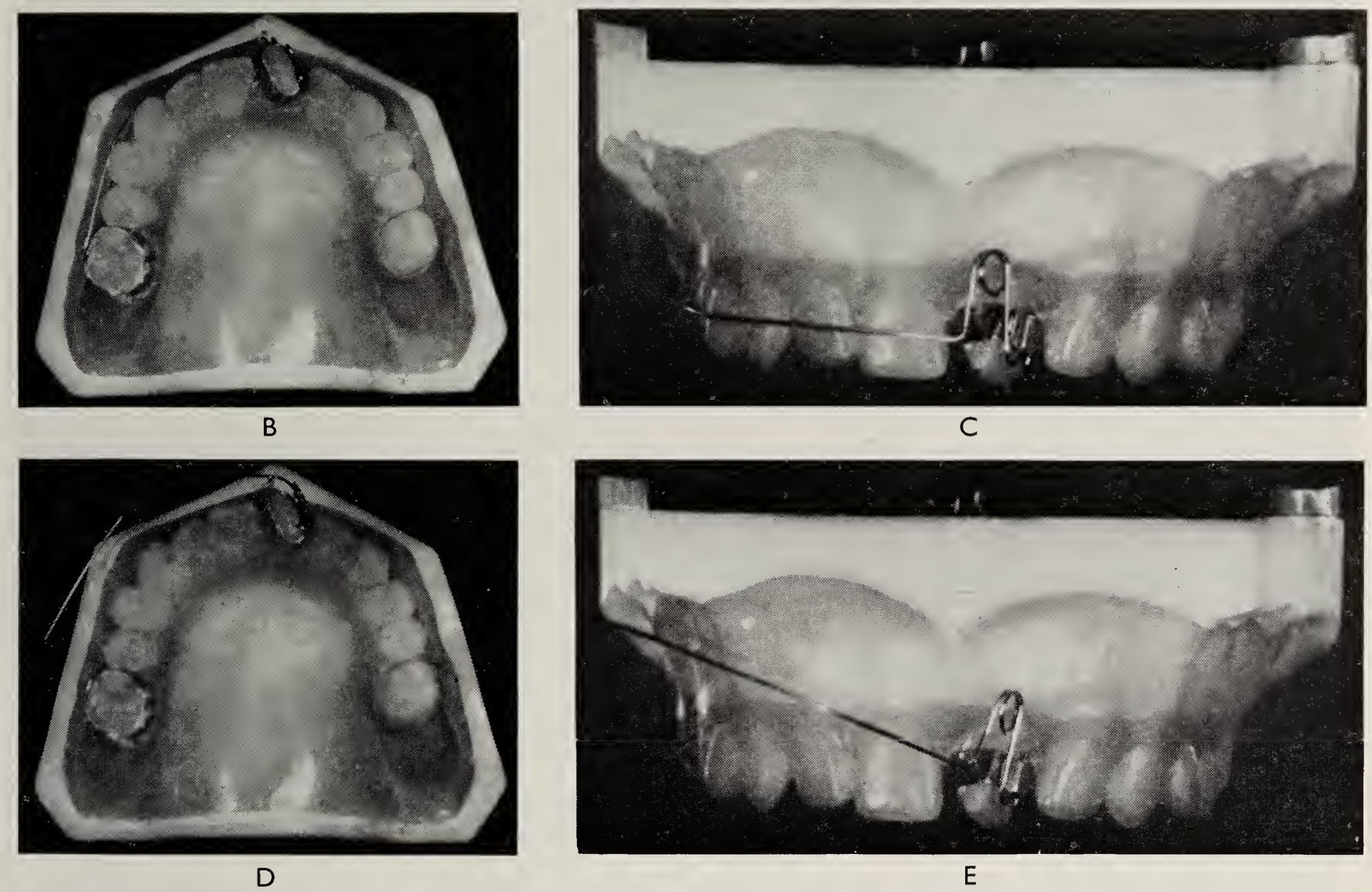
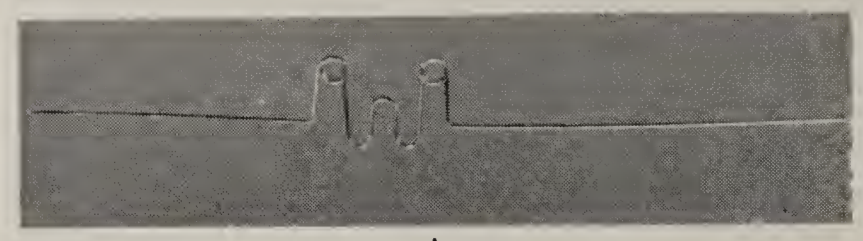


Fig. 3.—Single-end Watkin appliance used for rotation of a single tooth. A, The appliance is first bent in a flat plane; B, C, Showing appliance bent to lie passively in its attachment; D, Activated to rotate |1; E, Activated to upright |1 by tilting it distally.

This case illustrates well the use of the Watkin appliance for the rotation of a single tooth. It can, with rather more difficulty, be adapted to rotate two anterior teeth. Leighton (1963) has described its use to aline all four upper incisors, but I personally prefer to use other appliances for this purpose.

Fig. 3 illustrates the use of the Watkin appliance to correct such a rotation. The tooth to be corrected is banded, and a Watkin vertical tube welded to its labial surface, parallel to its long axis. The appropriate first molar is also banded, and a round horizontal tube of about 0·5 mm. internal diameter attached to its buccal surface. The archwire is constructed in high tensile wire of 0·45 mm. diameter, and the U-shaped pin bent close to one end, the extreme end then being bent round as shown, to lock the pin in place (*Fig.* 3A). Alternatively the tongue on the vertical tube may be used for its purpose. On the opposite side of the pin a vertical loop is bent into the wire, incorporating a single coil, as shown. The purpose of this is to increase the flexibility of the wire, the end of which then passes backwards to the molar band. The wire having been bent as shown in *Fig.* 3A, lying quite flat, it is then contoured in the horizontal plane, so that the two ends of the archwire lie quite passively in the vertical and horizontal tubes (*Fig.* 3B). It should

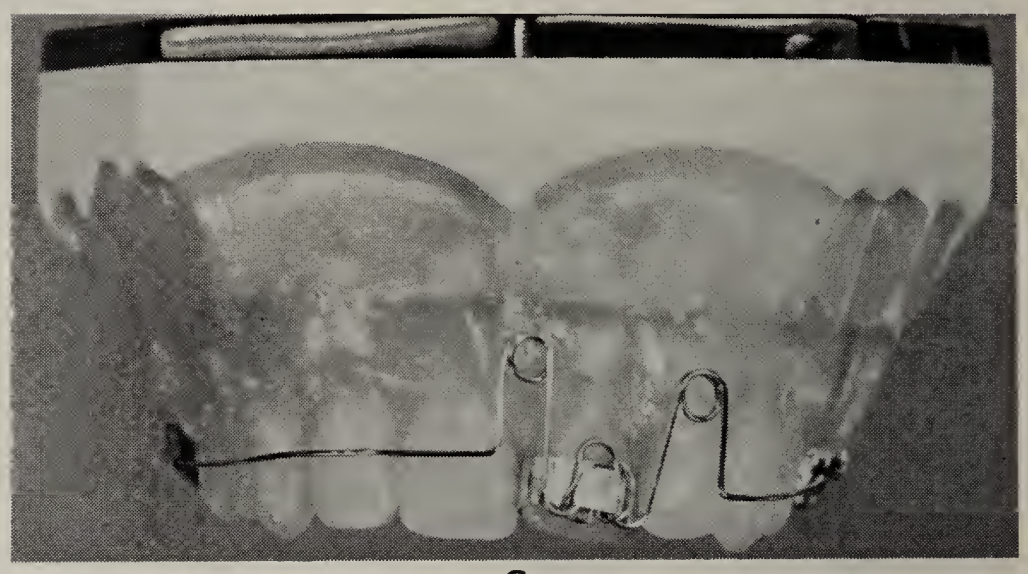
be checked in the vertical plane, inspecting it from the front, and adjusted until it is quite passive in this plane also, and re-checked in the horizontal plane to make sure that here also it is still passive.



A

Adjustments must then be checked in the vertical plane. Once again the pin is inserted in the vertical tube, when the end of the archwire should lie level with the horizontal tube on the molar band. If the incisor is tilted mesially or distally, the archwire may be used to upright the tooth, by bending it, again just distally to the vertical loop, in the appropriate direction, as shown in *Fig.* 3E. If any adjustments have been made in this vertical plane, the wire must again be checked in the horizontal plane, to ensure that the activation here is still satisfactory. One

B



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D

E

Fig. 4.—Double-ended appliance designed for rotation of a single tooth, while exercising more accurate control than with single-ended appliance. A, Appliance bent up in a flat plane; B, C, Adjusted to lie passively in its attachments; D, E, Activated to rotate and upright central incisor.

To activate it to produce rotation, the wire is bent outwards at the distal end of the vertical loop (*Fig.* 3D), adjacent to the incisor tooth, so that its distal end lies about 1 cm. buccally to the tube on the molar band. This will have an effect similar to the well-known 'whip' attachment used in fully banded techniques for the same purpose. The reciprocal action will be to move the molar buccally; the occlusion will usually prevent this, but it should be checked at each visit, and if there is any cause for alarm, the molar may be stabilized by the addition of a 1 mm. lingual arch on $\underline{6|6}$.

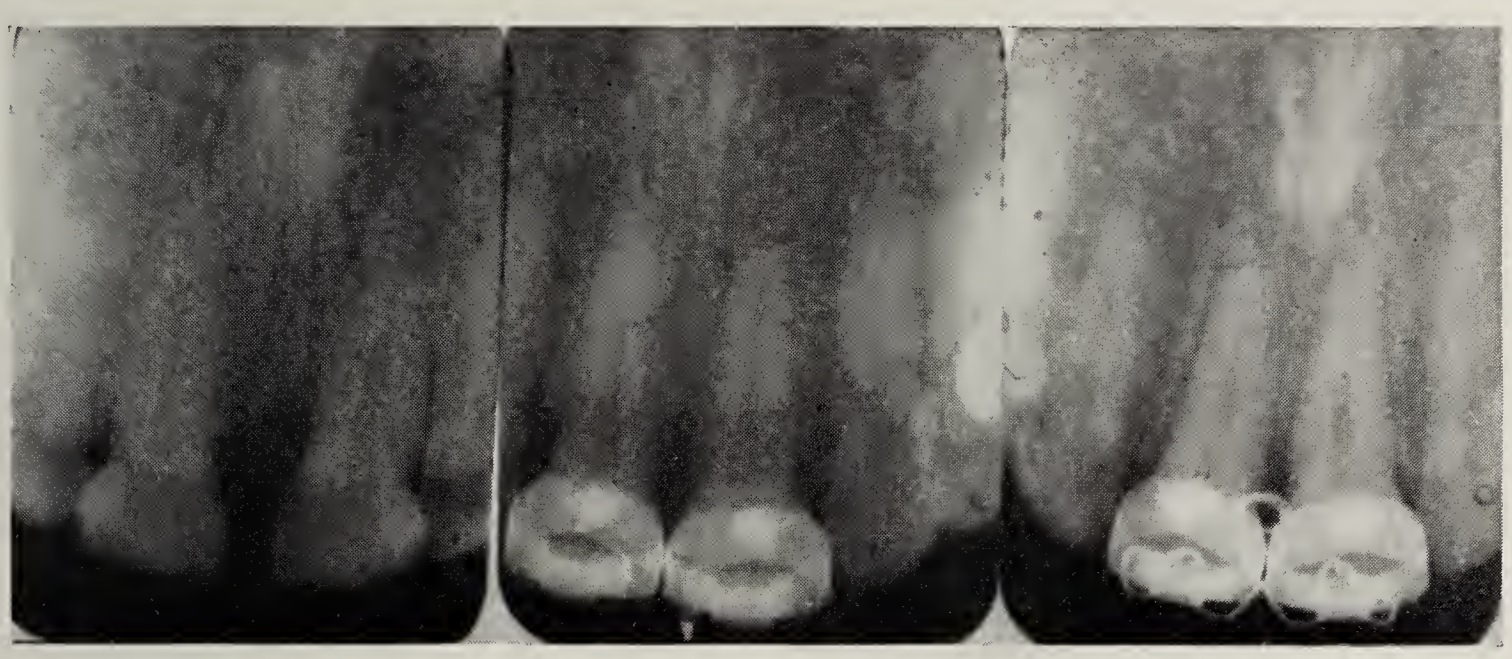
cannot stress too strongly the dangers of incorporating unwanted and unsuspected activation into these archwires.

Finally, the archwire is inserted fully, and the protruding end of the arch, distal to the horizontal tube on the molar band, is bent gingivally, to prevent its being accidentally dislodged.

This archwire may be used to achieve rough alinement of the tooth, but for final positioning, it is advisable also to band to the upper molar of the opposite side. The type of bilateral archwire shown in *Fig.* 4 is then fitted. This is essentially similar to the first one, but being bilateral allows

more precise control of the incisor tooth. Adjustment is essentially similar to that already described, except that bends must be made in both ends of the archwire, and even greater care is necessary to prevent the incorporation of undesirable adjustments.

the approximation of not only the crowns of the incisors but also their roots. This is illustrated in *Fig.* 5A. On the left we see the central incisors of a West Indian girl of 15 years. Although there is a wide diastema between $\underline{1|1}$, the teeth are mesially inclined, so that the roots are wider



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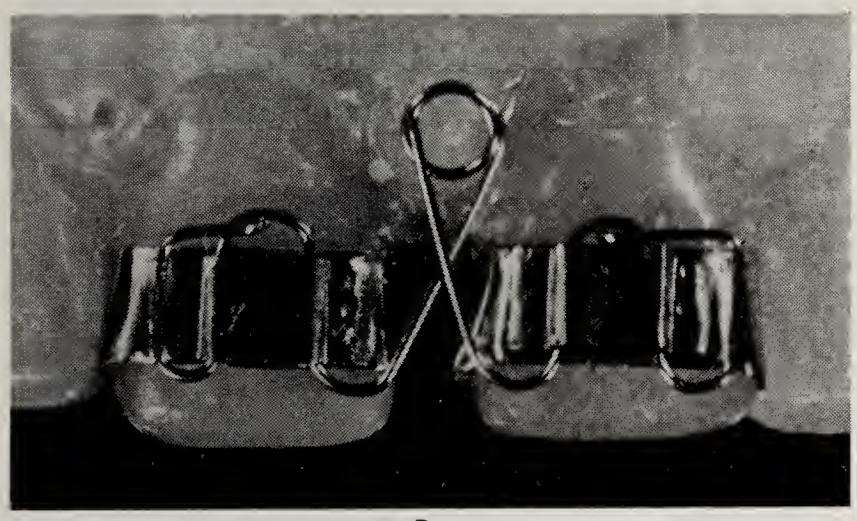

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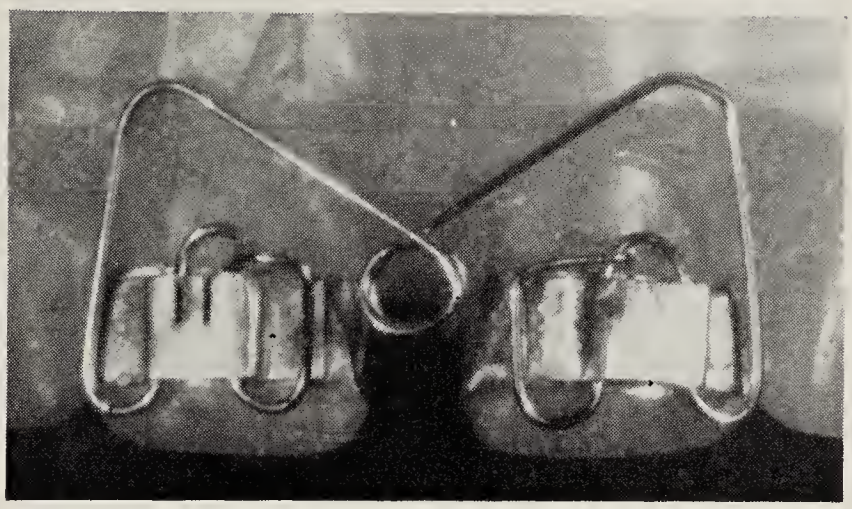


C

Fig. 5.—A, Intra-oral radiographs showing (left) $\underline{1|1}$ spaced and mesially inclined, before treatment, (centre) crowns in contact, and (right) crowns approximated and roots close together. Note bone deposition on distal sides. B, Appliance used for treatment shown in A; C, Modified appliance used where low fraenum is present.

Where the affected tooth is only slightly or moderately rotated, this bilateral type of arch may be used throughout treatment, but with a severely rotated tooth the single-ended type is invaluable in the earlier stages.

Reciprocal Movement of Anterior Teeth

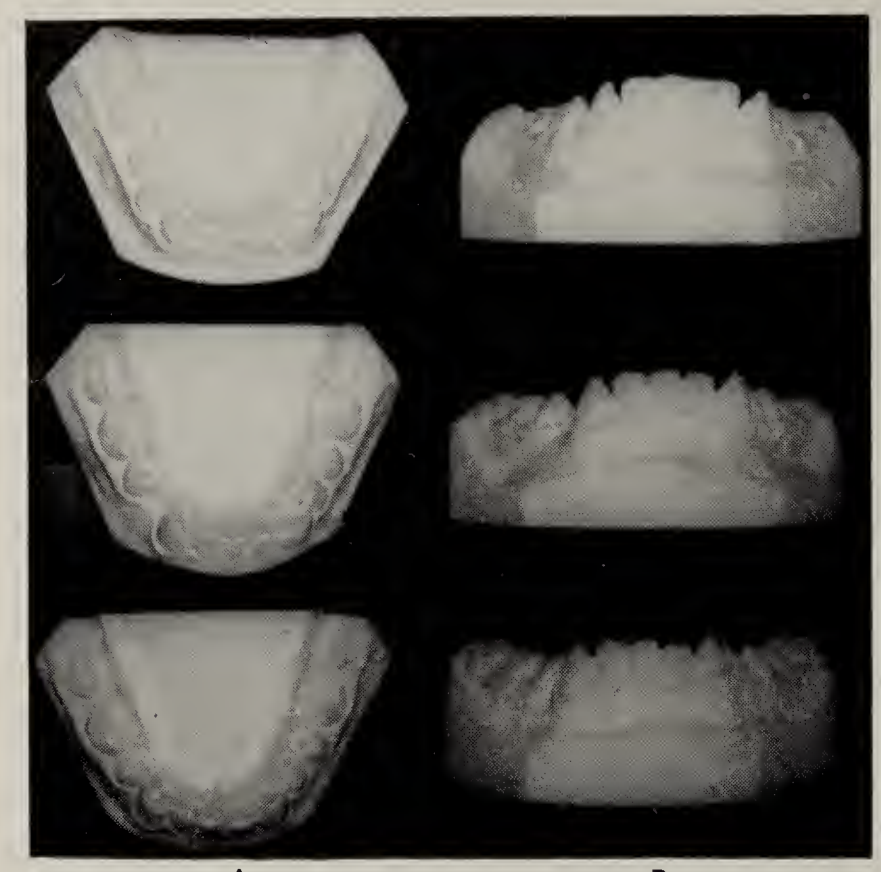
The Watkin appliance is frequently used in conjunction with bands on anterior teeth only, so as to produce local tooth movement by reciprocal action. The over-optimistic use of this type of ' local pin and tube ' has caused it to fall into disrepute in some circles, and I personally confine its use to local space closure.

Closure of an Upper Median Diastema

Where it is necessary to close an upper median diastema, such tooth movement usually requires apart than the crowns. These teeth were approximated by means of a local Watkin appliance, and it will be seen in the centre of the figure that their crowns came into contact with their roots parallel, and indeed treatment was then continued until the teeth were actually distally inclined, as shown on the right. Unfortunately, treatment of median diastemas involves more than mechanical ingenuity, and these teeth later relapsed completely, and have since been retreated and permanently retained.

The simplest form of the appliance, and the one used in this case, is shown in *Fig.* 5B. It consists of two pins, one to fit into the vertical tube on each incisor, with a closing loop between them. This is adjusted to approximate the teeth, with suitable readjustments from time to time. A difficulty with this type of appliance is that

sometimes the closing loop will impinge on the labial fraenum. Where this arises, it may be overcome by modifying the appliance as shown in *Fig.* 5C. This so-called ' M-spring ' is used in the same way as the previous appliance, but whereas the simpler form of appliance is made from 0·35 mm. wire, the longer M-spring should be constructed from 0·4 mm. wire.



A B

Fig. 6.—Lower arch treated by extraction of $\overline{|1}$. *Above* before treatment, *centre* at end of treatment, *Below* 1 year 8 months out of retention. A, Occlusal views; B, Anterior views.

Closing of Lower Spaces

The recognition of cases in which a lower incisor or canine may be extracted to relieve local crowding is a large subject, outside the scope of this paper. Where such an extraction is justified, the Watkin appliance may be used, in a manner similar to that shown above, to ensure that the adjacent teeth remain parallel during space closure.

Fig. 6 shows the lower models of a patient in whom the Watkin appliance was used, following the extraction of $\overline{|1}$. In this case it was considered desirable to move $\overline{|2}$ rather more than $\overline{1|}$ and therefore the appliance was constructed as shown in *Fig.* 7. Two teeth were banded on the right side, and only one on the left, so as to ensure that reciprocal movement was unequal on the two sides, as desired. Where this local type of appliance is used, one should have constantly in mind Newton's Third Law: ' To every action there is an equal and opposite reaction '. In designing the appliances, consideration should be given to the principles of ' anchorage balance ', and if necessary posterior teeth may be included in the anchorage.

In producing parallel space closure, the ends of the pins should be adjusted so as to converge, as shown in *Fig.* 7A. It is not sufficient to have them parallel in the active condition; they must be adjusted apparently to over-correct the position of the teeth. In addition, if used carefully, this appliance will bring about reciprocal alinement of teeth which are slightly displaced labially and lingually, as $\overline{|2}$ was brought forward in this case.

It will be noted that here, where narrow lower incisors are involved, I have used a narrower vertical tube on the incisor band. This was made from a privately constructed press to which I have access, but with care the standard size of tube may be used. In the present case, since no tongue was present on these locally-made tubes, it was necessary to ligate the pin into the tube, as shown in *Fig.* 7B–E.

The Principle of Lever Torque

This principle was first described and named by Clifford (1965). I have described a modification of the technique in a previous communication to the Society (Mills, 1967).

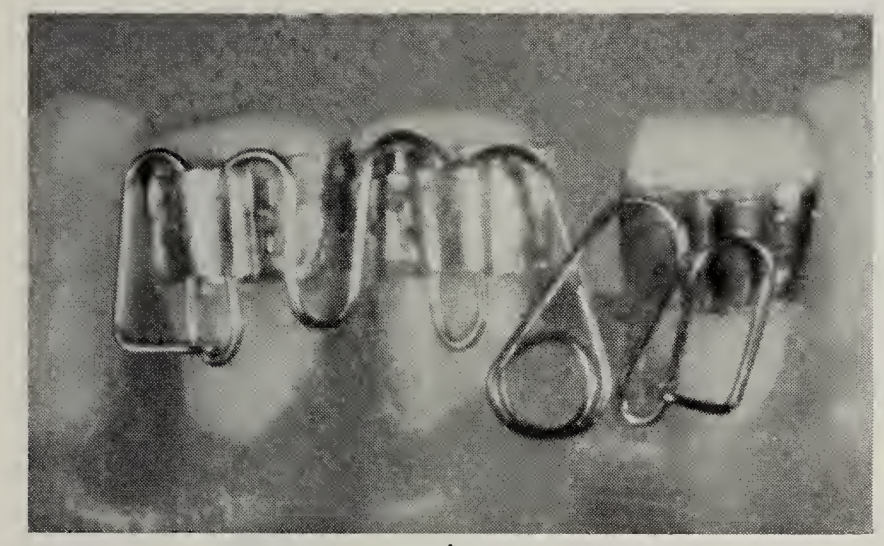
Case 2

Margaret (*Fig.* 8A) first presented for treatment in April, 1962. She had a mild Class III skeletal pattern, and there was a very marked contraction of the lower lip against the lower incisors and under the upper incisors in function. The posterior occlusion was very slightly post-normal (*Fig.* 8B), with a unilateral posterior cross-bite on the right side, accompanied by a slight mandibular displacement to that side on closing. The upper incisors were very proclined, with their apices lingually placed, and there was an increased overjet with complete overbite (*Fig.* 8C). There was an upper median diastema, and the dental bases were long, with no suggestion of crowding.

It was felt that, if the overjet was to be reduced permanently, it was essential that the upper incisal edges should be brought into contact with the labial surfaces of the lower incisors. This could only be achieved if, in addition to overbite reduction and lingual movement of the incisal edges of the upper incisors, their root apices were moved labially—normally an undesirable movement. Where such a movement is desired, the principle of lever torque is ideal.

The cross-bite was first corrected, and the upper posterior teeth moved distally into a ' good Class I occlusion ', using removable appliances and extra-oral traction. (I differ slightly from Clifford (1965) in my use of this technique in that I prefer to correct the canine relation, and where applicable to reduce the overbite, before using it.) When this had been done, the overjet was reduced by the method of lever torque, described below. In this case, however, the appliance also had a space-closing loop of the type shown in *Fig.* 5B, to simultaneously close the median diastema. At the end of treatment a fraenectomy was performed. Active treatment took 12 months, followed by 6 weeks retention. Apart from slight relapse of the cross-bite, the case has remained stable, the final records being 5 years 8 months out of retention.

This case illustrates the use of this form of lever torque. Once space has been made, both mesiodistally and, by overbite reduction, vertically, bands are fitted to the upper first molars, carrying horizontal tubes. Bands are also fitted on the central incisors, but not usually on the laterals.



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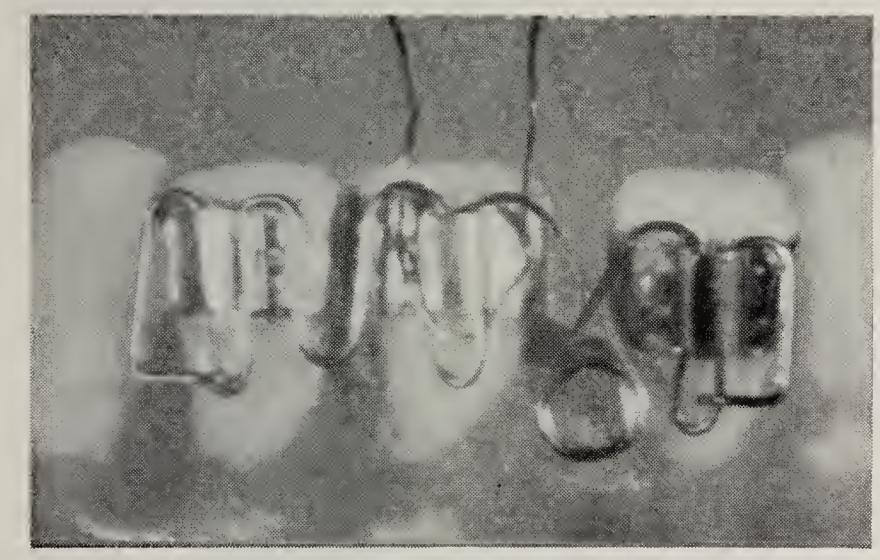

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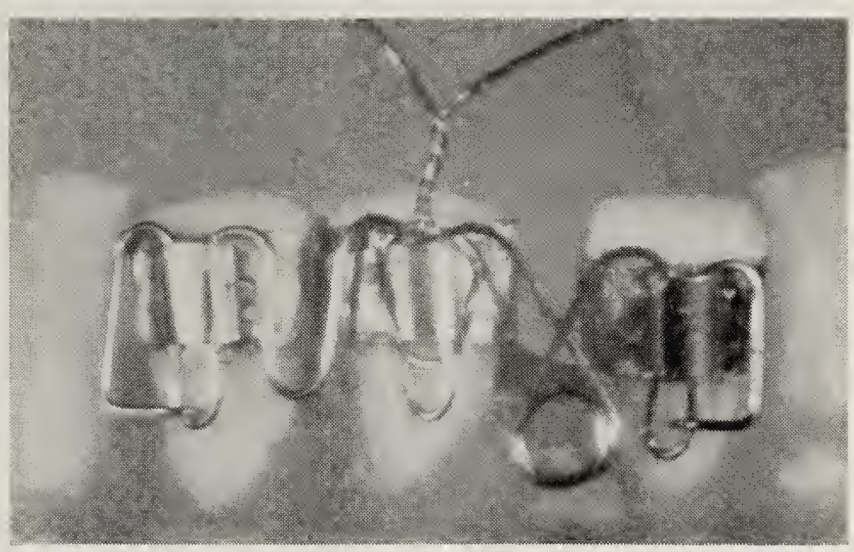

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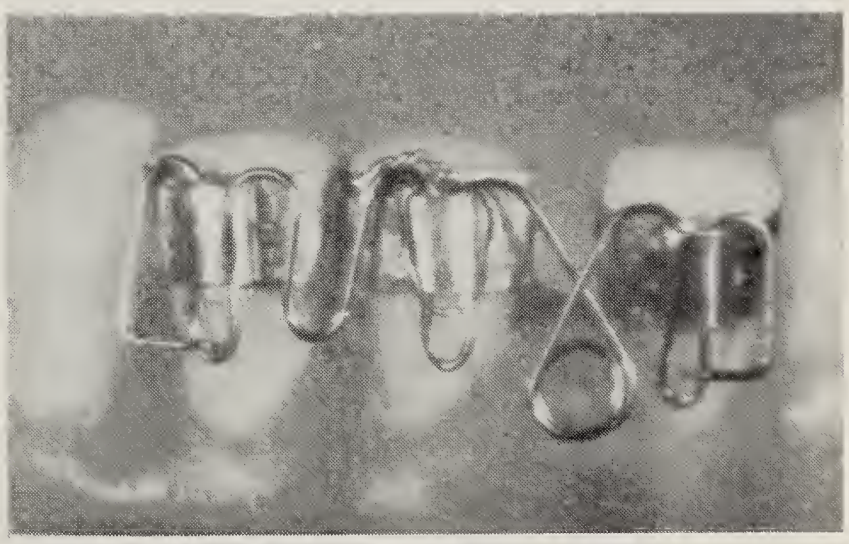


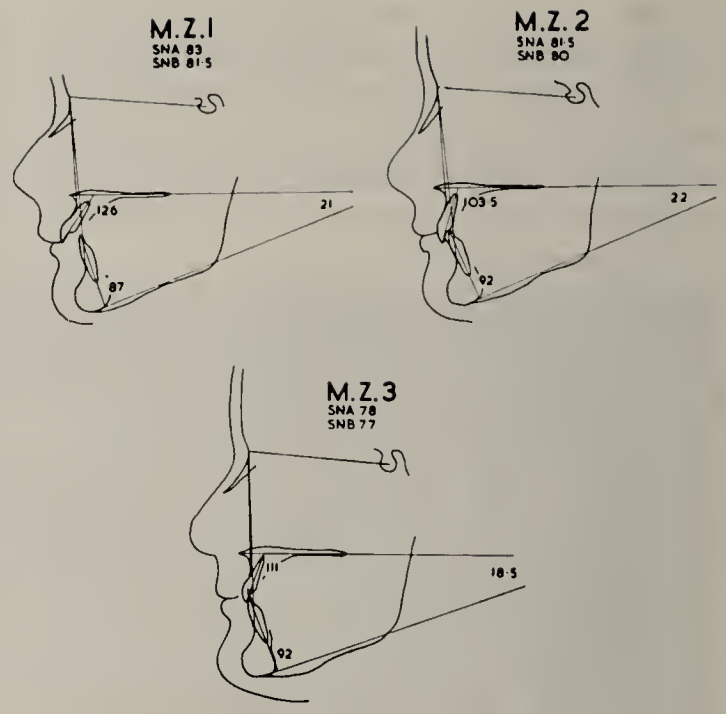
E

Fig. 7.—Local Watkin appliance used to bring about approximation and alinement seen in previous figure. A, Showing amount of over-correction used in activation of ' pin '. B–E, showing appliance in place, and stages in ligating ' pin ' into ' tube '.

The archwire is constructed from 0·45 mm. high-tensile wire, as shown in *Fig.* 9. The pins are bent to fit into the vertical tubes on the incisor bands, with an adjustment loop between them or, if it is desired to close a diastema, a closing loop. The free ends of the archwire are contoured around the arch, so as to lie passively in the tubes on the molar bands (*Fig.* 9A). Once again, the whole appliance should be passive, and it is especially important that the two pins should lie passively in their tubes, relative to each other. To activate the archwire, the free ends are bent downwards, occlusally, immediately distal to the pins so that, with the pins in the vertical tubes, the free ends lie about 1 cm. below the horizontal tubes on the molar bands, as shown in *Fig.* 9B. The pins are now removed from the vertical tubes, and the free ends inserted into the horizontal tubes. It will be seen in *Fig.* 9C that the pins are now more vertical than the tubes and, if inserted into these tubes, will tend to upright them, and therefore the teeth to which they are attached. Since the archwire can slide quite freely in the horizontal tubes, this uprighting will take the incisal edges lingually and simultaneously move the root apices labially.

However, before inserting the pins in the vertical tubes, but with the ends of the archwire in the horizontal tubes, one must check the vertical height of the pins relative to their tubes. If, as in the case described above, the lower lip-line is high, and intrusion of the upper incisors is

A



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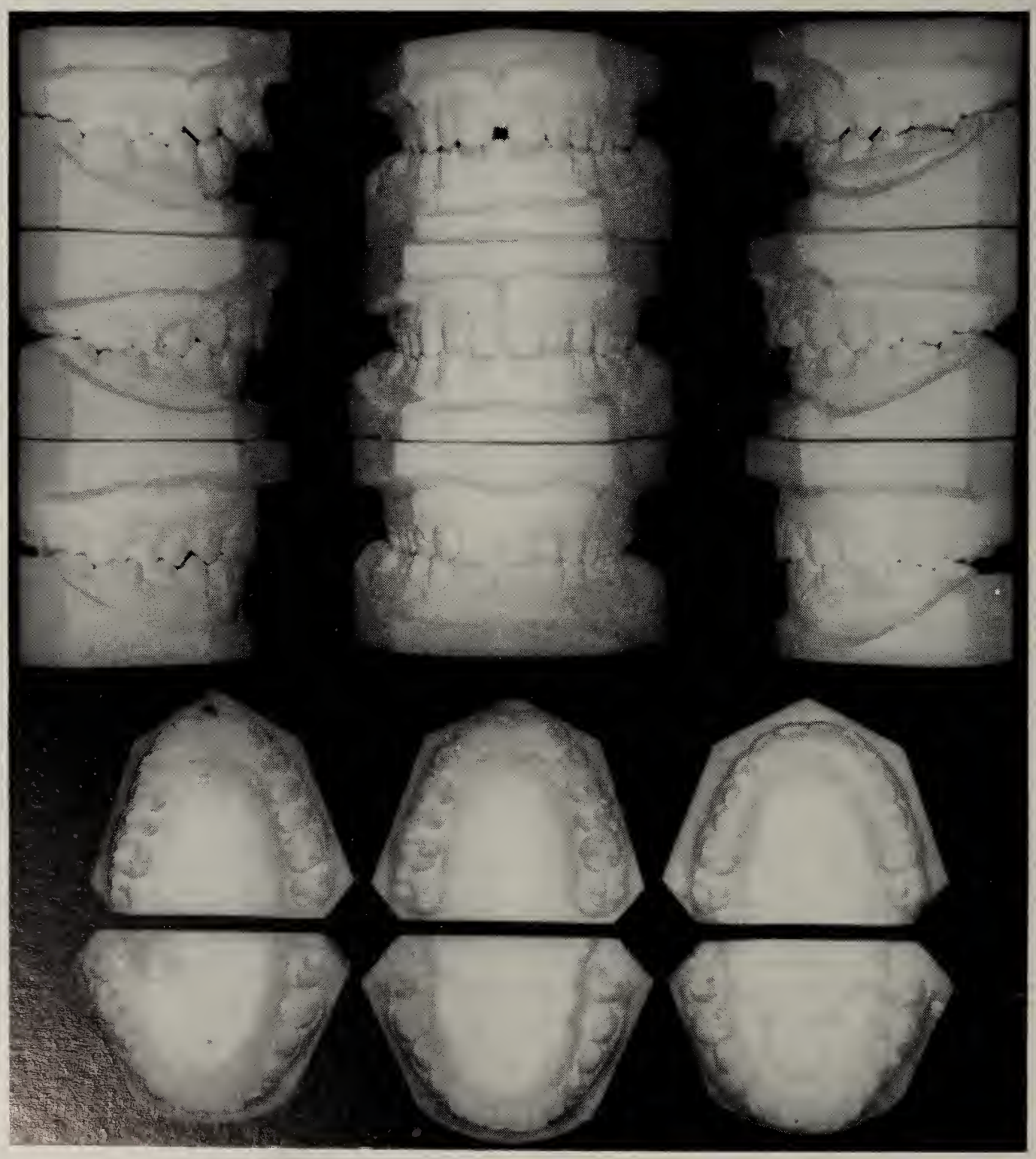


B

Fig. 8.—Records of *Case* 2. A, Photographs. Note excessive contraction of lower lip in smiling. B, Models, before treatment, at the end of treatment, and 5 years 8 months out of retention. C, Tracings of radiographs corresponding to the models.

considered desirable, then the archwire should be bent a short distance in front of the horizontal tube (but not immediately in contact with it) as shown in *Fig.* 9C. Unless this intrusion of the upper incisors is required, the pins should be in the same vertical plane as their tubes.

If any adjustments have been made at this stage, the arch must again be inserted in the vertical tubes, to check that the previous adjustments are still as required. When the archwire is satisfactory in both these positions, it may be finally inserted and locked into place.

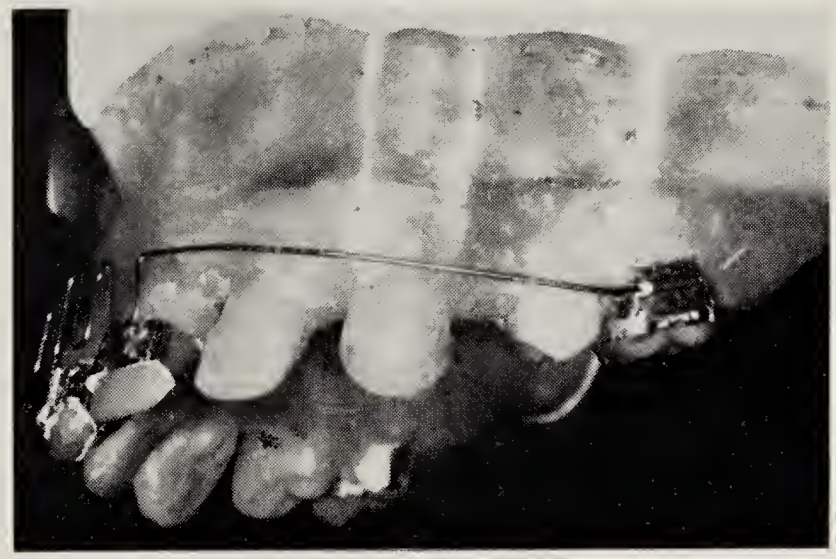
The teeth will then gradually become more upright, each tooth pivoting about a point within its root, and the ends of the archwire sliding distally through the horizontal tubes on the molar bands. These molar teeth serve to stabilize the arch, and the only reciprocal action upon them is a force to extrude them vertically, which in practice has no effect. If the ends of the arch have been bent as shown here, there will also be a tendency to tilt the molars distally, which is not usually objectionable.

It is seldom necessary to band the lateral incisors, the arch pressing on their labial surfaces being sufficient to move them lingually. At the end of treatment a slightly active retainer is useful for final alinement and closure of band spaces.

This same principle of lever torque may be used with the reverse effect, to prevent the labial movement of the incisor apices or to move them palatally during overjet reduction. I have described and illustrated this elsewhere (Mills, 1967), but a further case is presented below.

A

B



C

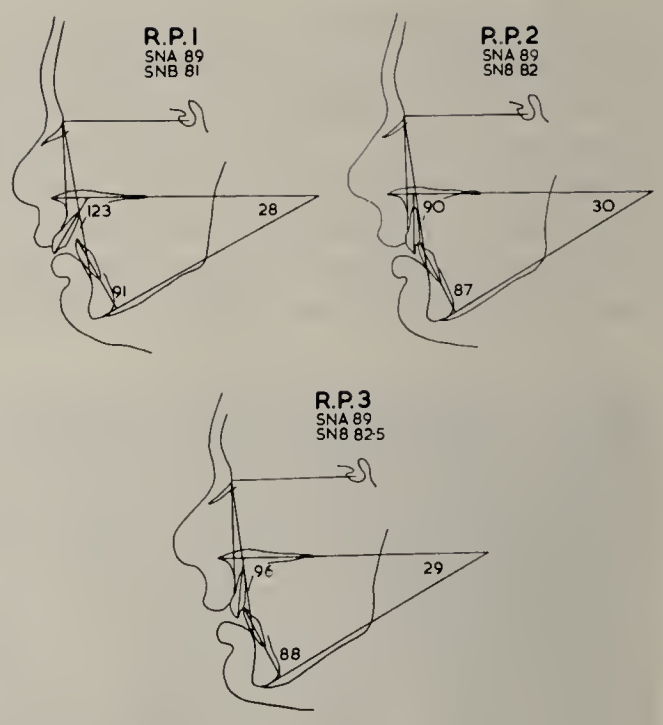
Fig. 9.—Watkin appliance using principle of 'lever torque' to move crowns of 1|1 palatally and their roots labially. A, Appliance in position but passive. B, Appliance activated by adjustment of distal arms occlusally. C, Ends of appliance inserted in tubes on molars, showing active position of 'pins'. This also shows the upwards activation of the archwire, where the intrusion of upper incisors is acceptable.

Case 3

Ronald (*Fig.* 10A) was first seen in December, 1965, when he had quite a severe Class II skeletal pattern, with a somewhat shallow lower facial height. His lips were very incompetent, with the lower lip resting under the upper incisors. These teeth were proclined to an angle of 123° to the maxillary plane, and there was an overjet of 12 mm. with the overbite complete on to the palate (*Fig.* 10B, C). The lower arch was severely crowded, but despite this the molar relationship was post-normal, especially on the right side. In addition, both upper canines, but especially 3|, had erupted mesially and labially to their correct position within the upper arch.

It was decided to extract all 4 first premolars, although it was realized that this would give barely sufficient space in the lower arch, and probably insufficient in the upper. An upper removable appliance was fitted to retract 3|3, carrying a bite plane to reduce the overbite. The spring pressures were kept very low to minimize tilting of the canines and also forward movement of the buccal teeth. Retraction of the canines and overbite reduction took 15 months, at the end of which time they were in contact with 5|5, but on the right side still not in an acceptable relationship to the lower canines. Considerable natural alinement took place in the lower arch, but in January, 1967, all the lower teeth were banded, and a 0·4 mm. lower archwire fitted to aline the lingually displaced |1. This lower archwire was then replaced in April, 1967 by a 0·45 mm. plain arch to maintain the reduction of overbite which had been produced by the bite plane on the upper removable appliance.

A



C

B

Fig. 10.—Records of *Case* 3. A, Photographs (taken at the end of treatment). B, Models taken before treatment, at the end of retention, and 3 months out of retention.

At this stage bands were cemented to $\frac{621|126}{}$, with an upper palatal arch to retain $\frac{3|3}{}$ in their retracted position. A 0·45 mm. Watkin appliance was fitted and used as described below. Intramaxillary traction was instituted between hooks on the upper archwire and the ends of the same arch where they protruded beyond the buccal tubes. The reciprocal

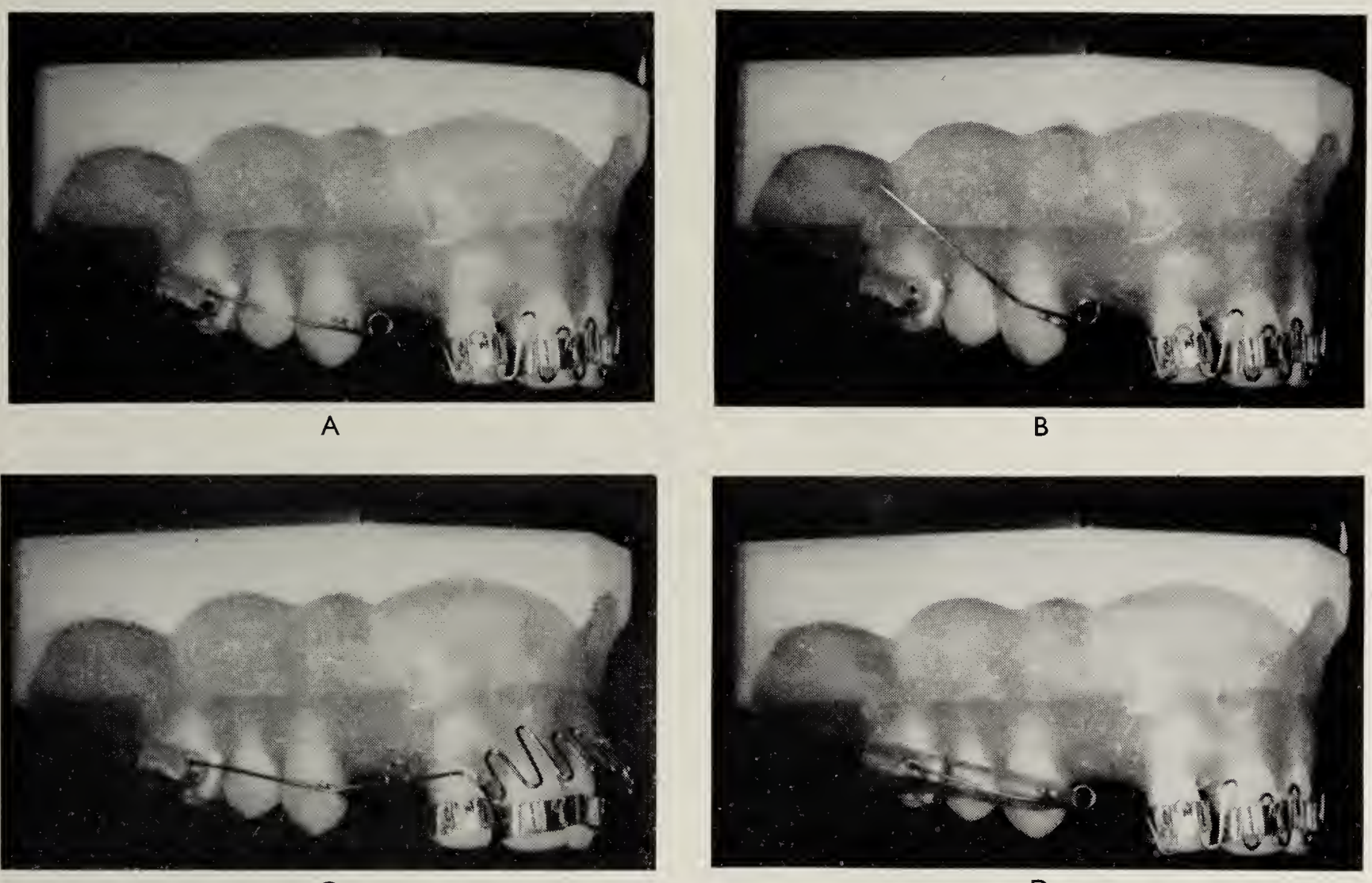


Fig. 11.—Watkin appliance using the principle of ' lever torque ' to move upper incisor apices palatally. A, Archwire in place but passive. B, Archwire activated by adjustment of distal arms, gingivally. C, Ends of appliance inserted in tubes on molars, showing active position of ' pins ', and upwards activation of anterior end of archwire. D, Archwire finally in position with elastic intramaxillary traction in place. A Kloehn bow will provide extra-oral traction to the lower tubes on the molar bands.

effect of this would be to bring forward the upper molars, so extra-oral traction was applied by means of a Kloehn bow fitting into second tubes on the molar bands, not only to balance this forward pull from the intramaxillary traction, but to move the buccal segments distally to produce a more satisfactory canine relationship. The patient was instructed that, should he be unable to wear the extra-oral appliance, in no circumstances should he wear the intramaxillary elastics. The purpose of this Watkin appliance was to ensure that, as the incisal edges were retracted, the apices did not move labially. This was considered essential in view of the marked skeletal discrepancy, and despite their severe proclination.

The bands were removed from the lower teeth in May, 1968, and the upper bands 2 months later, when the upper incisors were slightly over-retracted. The upper arch was retained for 5 months. The final records are unfortunately only 3 months out of retention, although the lower arch had been without appliances for 12 months. Apart from very mild crowding which developed in both arches, the result would seem stable; the patient has since been observed 6 months out of retention and shows no further change. However, it is too early to be certain.

The type of appliance used is shown in *Fig.* 11. In this case all 4 incisors were taken into the arch but in many cases it is sufficient to have pin and tube attachments on the central incisors only,

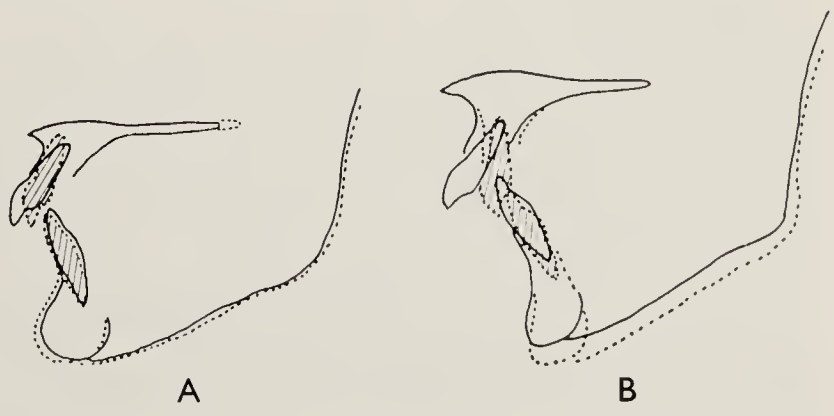


Fig. 12.—Tracings superimposed on the maxillary outline. A, *Case* 2, showing deliberate labial movement of upper incisor apices. B, *Case* 3, showing control of upper incisor apices.

which makes it very much simpler. If the upper lateral incisors are involved, then the pins for these teeth should be somewhat higher than those on the central incisors. Closing loops are placed between each pair of teeth, so that any spaces

may be closed as the teeth are retracted. The archwire is activated by bending it just behind the most distal pin, in a gingival direction (*Fig.* 11B); the reverse of the previous case. Considerable activation is necessary even where, as in this case, stabilization of the apices, rather than actual lingual movement, is required. The appliance is then checked, as previously, by placing the distal ends of the archwire in the horizontal tubes, and ensuring that the pins are in the correct vertical relationship to the vertical tubes (*Fig.* 11C).

Fig. 12 shows the two cases which have been used to describe the two contrasting uses of lever torque. In each case the radiograph taken at the end of treatment has been superimposed on the initial one, on the palatal outline. It will be seen that the first case shows considerable labial movement of the upper incisal apices, whereas in the second, by using the principle in reverse, the apex remains stationary.

CONCLUSIONS

1. In my hands the Watkin appliance is very useful in those cases where movements of small numbers of teeth involve rotations and/or root movements. Where only tipping actions are involved removable appliances are probably superior. Where multiple tooth movements are required, this appliance is inadequate and a fully-banded appliance is indicated.

2. Although comparatively simple in construction, the Watkin appliance is capable of doing considerable damage in unskilled or careless hands. In every case, and especially in the case of local appliances attached only to the incisor teeth, the principles of anchorage balance must be carefully followed.

3. As with nearly all archwires, the Watkin archwire should first be bent so as to lie in place with its attachments in a perfectly passive state. Only when this has been achieved should the activation be bent into the wire, according to the principles described above. It should then be carefully checked to ensure that the activation is not excessive, and that no unwanted activations have been accidentally incorporated.

Acknowledgements

I wish to thank those who have suggested various modifications which I have described in this paper, and especially to express my indebtedness to my teacher and friend, the late H. G. Watkin, who originated the appliance. I would also thank the postgraduate students and registrars of the Eastman Dental Hospital, London, who co-operated with me in the treatment of the patients used to illustrate the paper. Finally, I would thank the Photographic Department, the Eastman Dental Hospital, who took some of the photographs used, and Miss J. Jeffery for secretarial assistance.

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DISCUSSION

Professor B. C. Leighton's first comment was on the fail-safe device on extra-oral traction. There was one way of overcoming this. It was possible to avoid any chance of the elastic being hooked on to the arch itself by cutting this short, and not allowing it to protrude beyond the back of the molar tube, and protruding the extra-oral traction bow beyond the end of the tube so that the elastic would fix on to this.

He was not very happy about the possibility that anyone should attempt to tilt an incisor distally when using only one molar band. There was always a grave danger of the molar coming forward, and he would always feel happier to have two molar bands.

Did Dr. Mills find in any of his cases where he was using a local pin and tube to approximate two teeth that there was a tendency for them to rotate towards each other? He, Professor Leighton, always 'toed in' the two pins distally and lingually to prevent any sort of rotation mesiolingually.

Dr. Mills recommended only the banding of lower incisors when alining these teeth after extraction. He himself found that if there was any difficulty about unwanted tooth movement, it was safer to band also the canines. He then had complete control over the teeth, so that it was possible to limit the movement to one incisor.

Dr. J. D. Atherton was interested in the last case. Assuming that he had got the principle correct, it could be divided into two stages. Initially one proclined the incisors and then took them back. Would it be possible to do it the other way round, and simulate the Begg technique, tilting the incisal edge backwards, as had been shown in the previous cases, and then torquing the root palatally?

Mr. W. Marsh said that by pitting two incisor teeth against one, or something of that order, he found it possible to move a single incisor tooth through almost any required movement, without banding molar teeth at all. He made great use of Begg loops, and sometimes double Begg loops. He had used them in all quadrants of the mouth, not only the incisors, but also in the buccal segments.

Mr. D. DiBiase asked, when Dr. Mills approximated the central incisors, whether he had any trouble with bunching of the mucosa and adjustment of the

local appliance. If this was the case, how had it been overcome?

Mr. W. Senior said he noticed that Dr. Mills put the tube for the extra-oral traction on the occlusal side of the tube for the pin and tube appliance. If it was put on the gingival side, one got more retraction of the root of the first molar. Why was it put on the occlusal side?

Dr. Mills replied that Professor Leighton's suggestion for failing safe was a good one. He had done it, but the snag was that it was difficult to hook an elastic band on to the hook of the archwire with the extra-oral traction in place. If it was put on before the extra-oral traction was added, it would get knocked off.

He agreed with Professor Leighton about the tilting of the teeth. If one was going to upright a mesially or distally tilted tooth, it was better to have the archwire attached at both ends, and there was not often any reason why it should not be. For severe rotations, it was not always possible to have the archwire attached to both ends.

As for the local pin and tube producing rotations, Dr. Mills said he had not noticed this, but he would look for it. But it was important to check at every stage that the things were happening that one wanted to happen.

He had not stressed the alinement of lower incisors, because he did not use this appliance for it a great deal, although he knew that Professor Leighton did use it for the alinement of incisors. If he himself had to aline a number of teeth, he used other appliances.

Dr. Atherton's suggestion was a matter of opinion. Dr. Mills thought that the idea of taking the crown of the tooth back first and then the apex was one of the many shortcomings of the Begg technique. He personally moved the whole tooth as near as he could in the direction in which he wanted it.

Bunching of the mucosa was a feature which did occur. Various people had shown that the mucosa moved with the tooth. If one moved the mucosa with the teeth on both sides, there was bunching in between. He thought there would be less if it was done more slowly. One had to just hold the teeth until the bunching disappeared.

Mr. Marsh was able to use the technique with great skill but people with less skill could easily get into a great deal of trouble. If the pin and tube technique was going to be used, then one must work out precisely what was going to happen in terms of anchorage of the appliance. It was no good saying, ' I want this end to move but not that end '.

In answer to Mr. Senior, Dr. Mills said he did not think it made much difference which side the extra-oral traction was put. He thought it was easier to insert on the occlusal side, and that was why over the years he had put it on that side.

THE NATURAL HISTORY OF MALOCCLUSION

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Consultant Orthodontist, Portsmouth Hospital Group

In thanking the Council of this Society for the honour they have done me in inviting me to give this twenty-third Northcroft Memorial Lecture I feel a deep sense of my own inadequacy to present a theme which, though it seemed clear enough at the beginning, has developed in so many directions since I commenced to prepare the paper that I now feel I can do justice to none of it. George Northcroft was not only a clinician; he was deeply interested in the biological background to malocclusion and I feel sure he would have approved the subject—if not the lecturer.

Reduced to its simplest terms malocclusion may be due to one or more of the following factors:—

1. Discrepancy between the size of the teeth and the size of the dental arches.
2. Variations in anteroposterior dental base relationship.
3. Variations in soft-tissue morphology and function.
4. Idiopathic tooth displacement.

Taking these factors in reverse order the last is well known to exist in other animals, particularly in the case of the upper canines which seem to be more prone to erupt ectopically than other teeth even when ample space is available. In relationship to malocclusion, soft tissues in animals have not been studied at all; in skeletal material they are obviously not available and any deductions from the teeth must be tautological. Overcrowding of the teeth due to the first factor will be the main theme which I shall discuss in the context of malocclusion in wild animals and past and present human and hominid populations and of the genetic background, relating these to comparable biological phenomena.

ANIMAL OCCLUSIONS

Sir Frank Colyer devoted a substantial part of his incredibly full life to the study of animal skulls in collections all over the world for he felt that here lay the keys to our knowledge of dental pathology, malocclusion, and caries. His carefully documented findings were recorded in the Dental Board lectures of 1931 and in his book, *Variations and Diseases of the Teeth of Animals*, five years later (Colyer, 1936).

Malocclusion was an extremely common finding and was present in a wide range of species (*Figs.* 1, 2). In *Cercopithecinae* the total malocclusions are almost halved if premolar rotations, to which the genus is prone, are excluded. Colyer records only one case of Class II, division 1 incisor relationship in *Cercopithecus sabeus* (*Tables I, II*). Colyer's statistics, summarized in these tables, indicate an appreciable incidence of malocclusion in the non-human primates; in fact, the differences between these and human malocclusions are more of type and severity than of incidence—in particular, variations in dental base relationship are less common in apes than in man. Nevertheless even in type and severity of malocclusion there is a definite similarity between ape malocclusions and those found in Eskimoes by Newman (1952).

THE ANCESTORS OF MAN

The evolution of cusp form has been the subject of one of Dr. Mills' fascinating papers to this Society and I would not care to trespass on this ground which he has made his own (Mills, 1955, 1963, 1965). In fact, in order to keep this paper to a reasonable length, I shall continue to confine my remarks, not to occlusion, but to malocclusion.

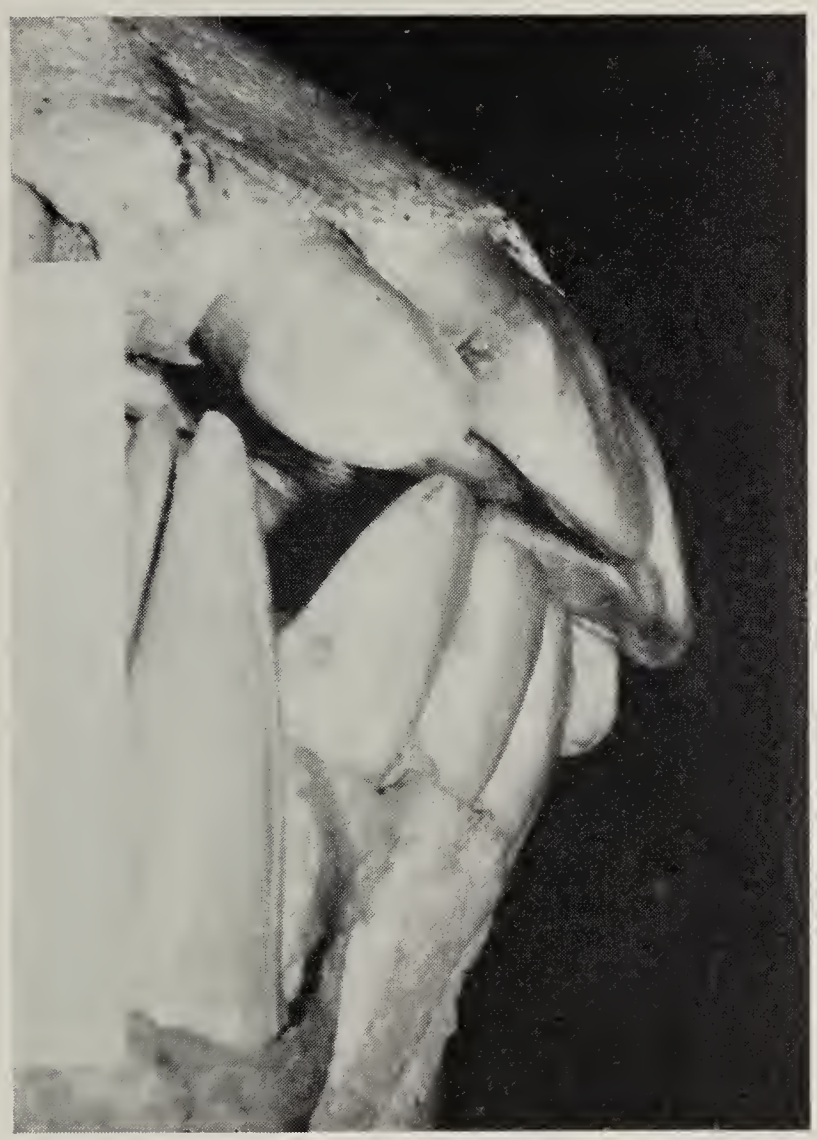
In trying to make any assessment of man's progenitors, the magnitude of the task is made clearer if we realize that the period we are considering is of the order of thirty million years, that the actual numbers of individuals in each species was infinitesimal in comparison with the numbers of modern man, and that the numbers of ' cul-de-sacs ' or species which died out leaving no descendants was far, far greater than the numbers of species which survived. Add to this the fact of the rise and fall of land masses into and out of the sea and the scouring of the earth's crust by rain, ice, wind, sea, and sun and it seems quite incredible that any evidence of their mere

Twenty-third Northcroft Memorial Lecture presented at the Country Meeting held in Leeds on 11 April, 1969.

existence remains for us to examine at all. On the other face of the coin our own particular interest is served by the fact that, of all animal tissues, teeth are the most indestructible; in fact, if ever a picture of primate evolution is constructed in the future it is most likely to be based on tooth structure.

Prior to the Miocene there are no primate remains which show any Hominid affinities at all but in the early part of this period lived a genus of apes called *Dryopithecus*, which could well have been on the line from which man developed. *Dryopithecus* is of interest to dental anatomists for two reasons: firstly because it is known, except

A



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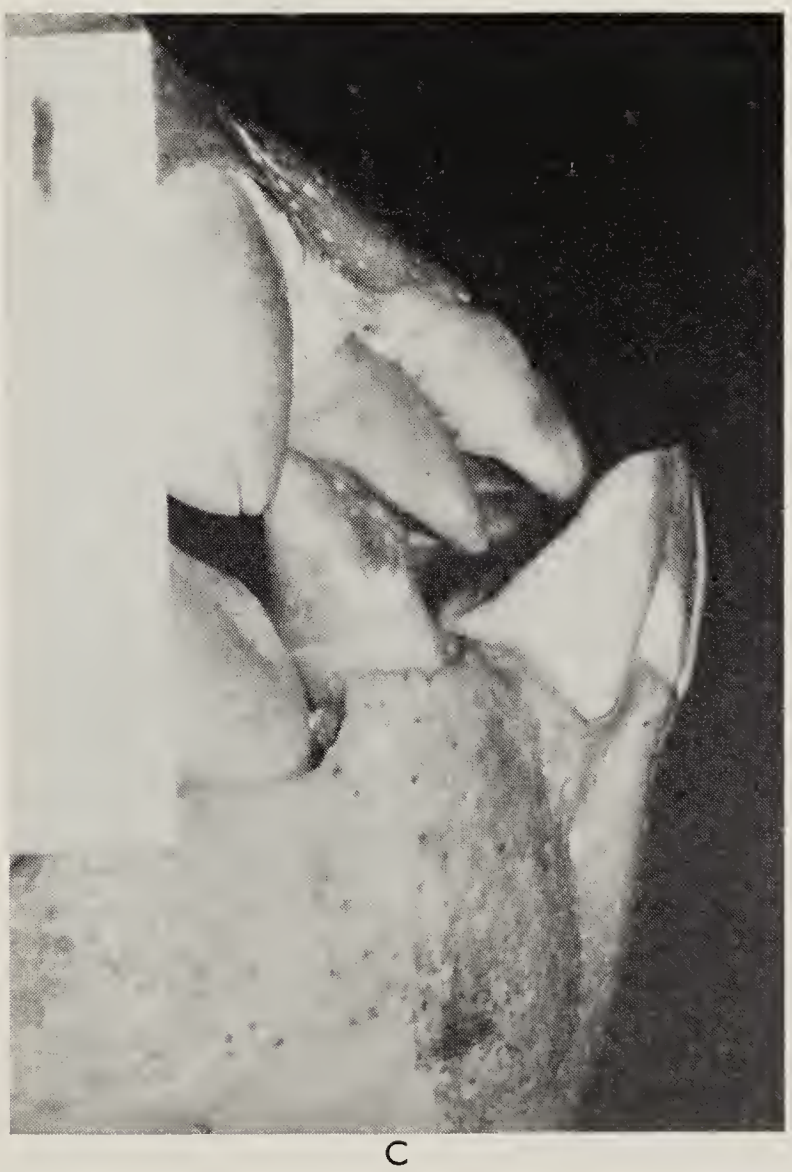

C

Fig. 1.—Malocclusion in wild animals: *Gorilla gorilla gorilla.* A, Edge-to-edge bite with incisor irregularity. B, Class II, division 1 incisor relation. C, Class III incisor relation.

for one humerus and one femur (which are not universally accepted) only by its teeth and jaws; and secondly because the genus shows an exceptionally wide range of tooth and jaw morphology and variability itself provides good material for natural selection to work on.

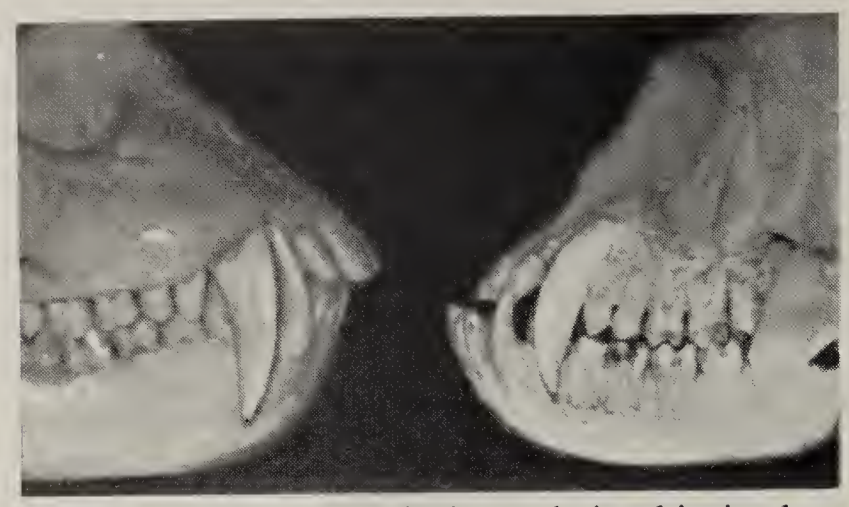

Fig. 2.—Variation in incisor relationship in the Green Monkey, *Cercopithecus aethiops sabeus.*

Table I.—Positional Variations in Teeth of Different Orders (after Colyer)

Order	Percentage Varying
Primates	27·3
Carnivora	6·4
Rodentia	0·7
Ungulata	12·1
Hyracoidea	12·3
Marsupialia	3·2

2. Replacement of the sectorial lower first premolars by bicuspid teeth with later secondary reduction of the lingual cusp.

3. Alteration of occlusal relationship with the result that especially in later forms all the teeth become worn flat.

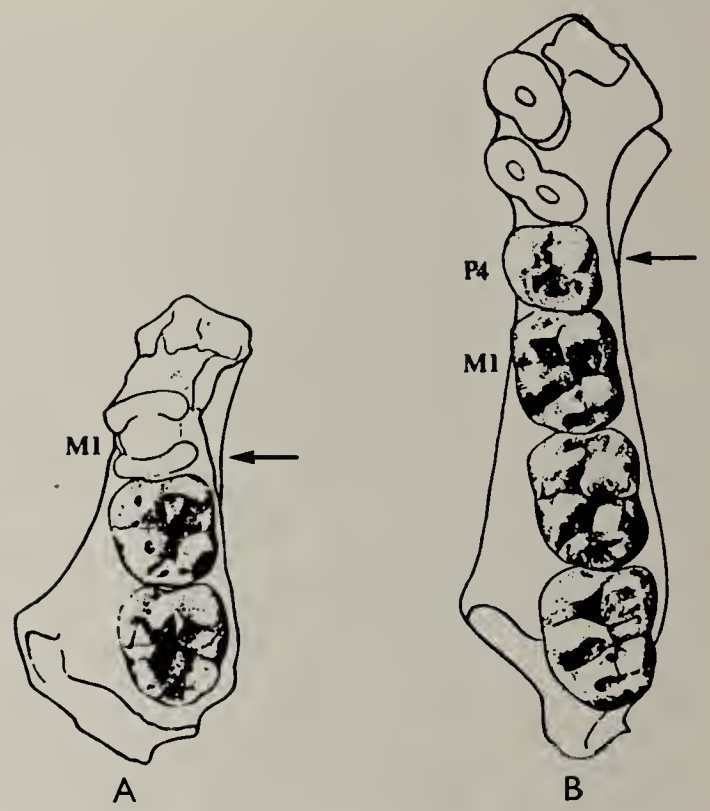

Fig. 3.—Mandible fragments of *Ramapithecus* (A) and *Dryopithecus* (B). In the hominid the medial mandibular border begins to turn toward the midline at the first molar whereas in the ape this curve does not commence until the second premolar (after Simons, 1964). (*Figs.* 3, 4, *reproduced from Campbell, B. G.* (1967), '*Human Evolution. London: Heinemann.*)

Table II.—Incidence of Malocclusion in Primates (Modified from Mills after Colyer)

Super Family	Genus	Percentage Varying	Class III Incisors
Apes	Gorilla	31·6	2·7
	Pan	22	4·5
	Pongo	25	1·1
Old world monkeys	Colobinae	40·6	24·1
	Cercopithecinae	30·3	0·3
New world monkeys	Cebidae	17·7	11·7
	Hapalidae	9·5	Nil
Prosimii		12	N.A.

Le Gros Clark (1964) defines the *Hominidae* on the basis of their morphological patterns, and in respect of the teeth he notes the following:

1. The canines are diminished in phylogeny to a spatulate form with little or no interlocking, showing no sexual dimorphism, and with disappearance of the diastema.

4. Development of an evenly rounded dental arcade.

5. A marked tendency in the later evolutionary stages to a reduction in the size of molar teeth.

6. Progressive acceleration in the replacement of deciduous teeth relative to the eruption of the permanent molars.

None of the *Dryopithecines* cross the Hominid borderline and it is difficult to follow their successors (if any) towards the next stage, the pre-hominid genus *Ramapithecus*. A number of factors place this latter genus fairly in the line of Man's ancestors. *Fig*. 3 compares the mandibles of these two animals and shows how the inner curve of the mandibular body turns medially much further back in the later species—a stage further towards the short jaw of modern man.

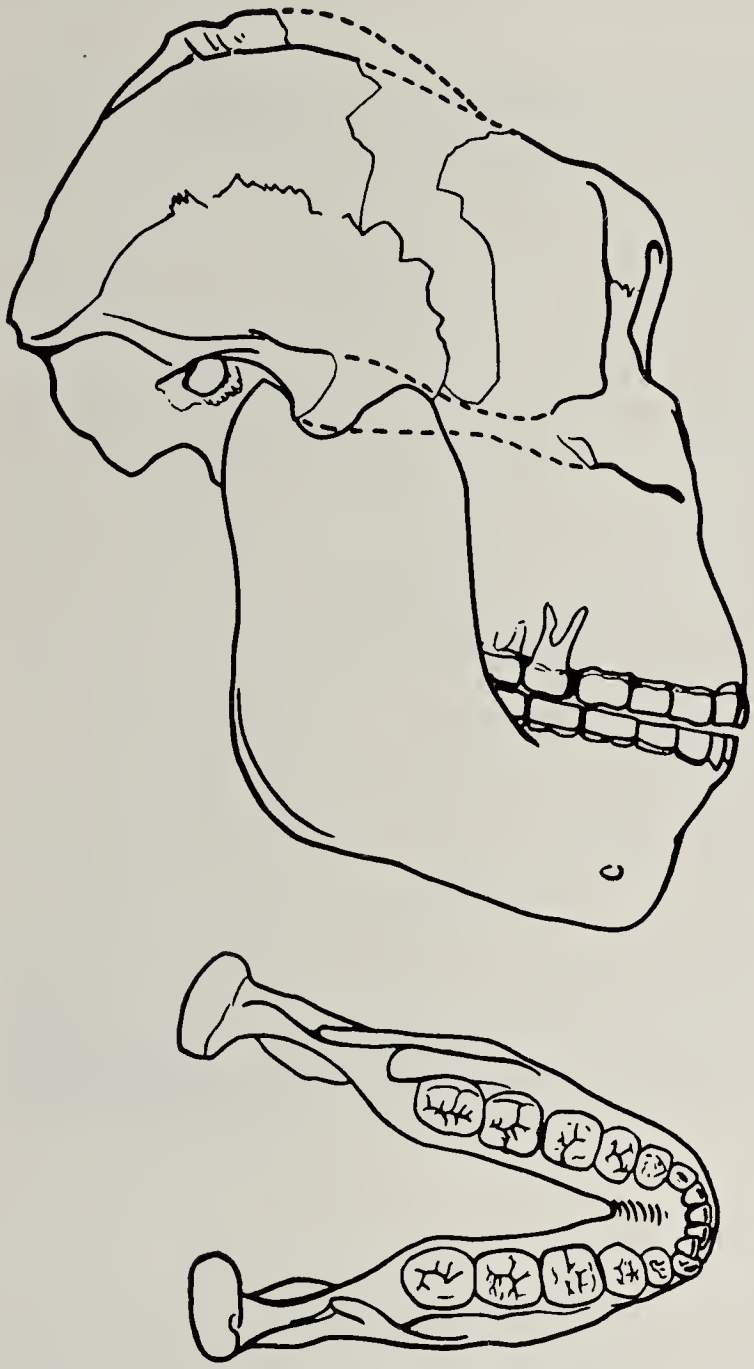

Fig. 4.—*Australopithecus robustus*. Note crowded lower incisors despite massive jaws. (Drawn from a photograph of the Olduvoi specimen; the mandible is from Swartkraus.)

Further probability of *Ramapithecus* being truly in the Hominid line is evidenced by the very wide distribution of the genus. Specimens found in India closely resemble those found in South Africa. Such a wide spread would make it likely that changes in environment would lead to many lines of succession.

In the same general area as *Ramapithecus* was found a more recent genus with a number of distinct species—the Australopithecines, which belong to the late Pliocene and early Pleistocene. The genus is variable but in general shows massive jaws, spatulate canines, relatively large premolars and molars, lower first premolars with unequal cusps, and a progressive increase in molar size from before backwards. The dental arch is parabolic and no diastema is present. Of special interest is the heavy jawed *Australopithecus robustus* (*Fig*. 4). In this species and in *Australopithecus boisei* (*Zinjanthropus*), the maxilla of which is illustrated in *Fig*. 5, the tight contacts between the teeth and the tendency to overcrowding have attracted the attention of the anthropologists who describe them. In his description of *Zinjanthropus* Tobias (1967) suggests that this is due to an imbalance between two opposing morphologic tendencies, one for a flattening of the face or shortening of the muzzle and the other due to enlargement of the molars for masticatory reasons. Robinson (1956) discussing the general features of *Australopithecus robustus* remarks on the complete absence of all spaces. He states that ' a general characteristic of the pre-hominid dentition which may also suggest crowding and space shortage in the jaw is the degree of wear at the contact facets.' He goes on to say, significantly, that the disparity in size between the small incisors and canines and relatively huge cheek teeth ' seems to be a consequence of the need for tooth reduction to accompany reducing jaw size, coupled with selection for large cheek-tooth occlusal area in relation to a vegetable diet.'

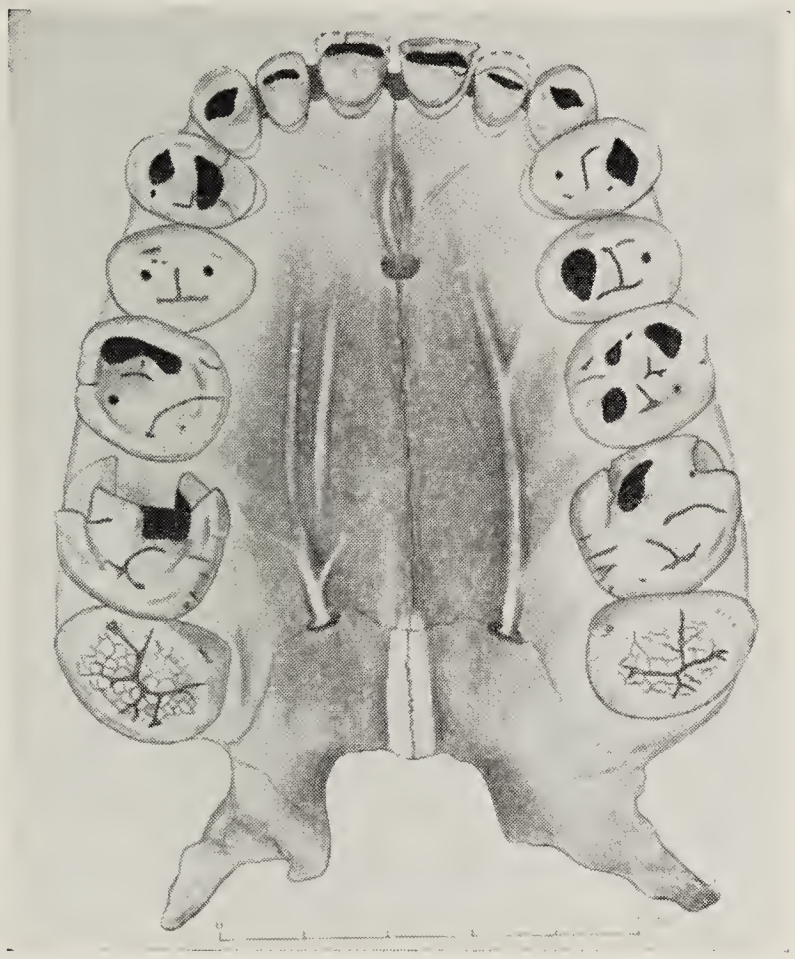

Fig. 5.—Maxilla of *Zinjanthropus*. There are tight contacts between all teeth. The apparent spaces are due to post-mortem loss of enamel (*after Tobias*, 1967).

I find it difficult to accept that a reduction in jaw size *per se* could be necessary or advantageous. This factor will be discussed at greater length later in this paper.

These creatures were completely bipedal and walked upright as does modern man, but they were shorter and more thick-set. At present they are regarded as beside the main stream of human evolution, though not greatly displaced from it. Certainly they chipped pebbles in order to make them into sharp-edged tools, though it is not clear for what purpose. Their cranial capacity was not very much greater than that of a modern chimpanzee.

Table III.—Crown Length of *Homo erectus pekinensis* (after Weidenreich)

Tooth	Crown Length (mm.)	
	Upper teeth	Lower teeth
Central incisors	9·8–10·8	6·0– 6·8
Lateral incisors	8·2– 8·3	6·3– 7·2
Canines	8·5–10·5	8·1– 9·0
First premolars	7·4– 9·2	7·9– 9·8
Second premolars	7·2– 8·9	8·2– 9·2
First molars	10·0–13·1	9·9–13·6
Second molars	10·2–12·2	11·3–13·1
Third molars	8·7–10·2	10·0–13·8

A group of hominids found in the Middle Pleistocene in China and in North and East Africa have been placed in the genus *Homo* and are now lumped together as races of a species called *Homo erectus*. In a cave at Choukoutien near Peking was found a number of individuals of a race formerly called *Sinanthropus* but now generally *Homo erectus pekinensis* (Campbell, 1967). *Homo erectus* was a polymorphic species and varied greatly in size—and in size of teeth. Sexual dimorphism was much more marked than in any race of modern man. Among the Choukoutien remains was a large number of teeth. Weidenreich (1945) examined 147 of these, of which 64 were isolated specimens They were believed to have come from about 32 individuals. *Table III* illustrates their most striking feature, a wide variability in tooth size especially in the molar region.

Probably the earliest example of *Homo sapiens* and certainly the ' oldest Englishman ' was discovered by A. T. Marston, a dentist and, I believe, a member of this Society, at Swanscombe in Kent; it is believed to date from the Middle Pleistocene (200,000 years B.P.). Unfortunately the teeth and tooth-bearing areas are not present. From the Upper Pleistocene a number of skulls have been discovered in the valleys of the Dordogne and Vézere rivers in France. Some are complete and quite modern in all appearances, being similar to those of modern Basques. Contemporary with these, the Cro-Magnon race, lived the famous Neanderthal man with his heavy jaw and thick brow-ridges. What happened to him we do not know but evidence of such characteristics as taurodont molars in modern man have led to the suggestion that he may have interbred with *Homo sapiens* before he disappeared entirely.

Mention has been made of the fugitive nature of hominid remains but from *Australopithecus* onward he left behind much more permanent evidence in the form of stone tools: every man would make at least several hundred in his lifetime so their numbers would be great and they are almost indestructible. Much more is known therefore of population drift from stone artefacts frequently dated by carbon remains in the hearths they left behind.

From the late Paleolithic onwards, sufficient numbers of *Homo sapiens* were in existence to leave remains from which generalizations could be made of changes in the morphology of populations—at least in their grosser aspects: one of these which is of interest is the cephalic index. All the early skulls were dolichocephalic, brachycephalic specimens appearing only very occasionally before Mesolithic times when they became relatively common (8 out of 21 skulls from the Ofnet graveyard were brachycephalic). Most of the Neolithic immigrants to Britain were long-headed but in the later Bronze age the invading Beaker Folk were predominantly (though not entirely) round-headed; they came from Asia Minor, Central Europe, and Spain. A swing in the opposite direction again occurred in the Iron Age and in the early part of the Roman invasion, though when the Romans left brachycephaly was characteristic of the residual population.

It is interesting to note here that Huizinga (1958) regards brachycephaly as a form of neoteny or prolongation of infantile characteristics into adult life. This would accord with the enormous extension of man's parental dependency. In the present context it is merely used as a method of recognition of population change.

For any group of animals to differ from its neighbours sufficiently to form a new species, a long period of physical or biological isolation is necessary. This isolation may be sharp and well defined as in the case of a remote island or it may be very gradual: although it is possible to walk all the way from Siberia to Spain the great distance prohibits gene flow. The classical zoological example of such restriction in gene flow is seen in the two gulls common on our shores, the lesser black-backed gull and the herring gull, *Larus fuscus* and *Larus argentatus;* the first has near-black wings and the second light silver-grey wings with black tips. There are also differences in bill and leg colouring. Following the herring gull eastwards around the world

a series of races or subspecies is encountered each with wings slightly darker and browner than the preceding one until on returning to Western Europe the species becomes the lesser black-backed. Here, at the ends of the range the two species are entirely and obviously distinct and do not interbreed although there is considerable overlap of habitat. Such a gradual morphological change is known as a ' cline ', and

Fig. 6.—Instrument used for direct measurement of angle ANB on skulls.

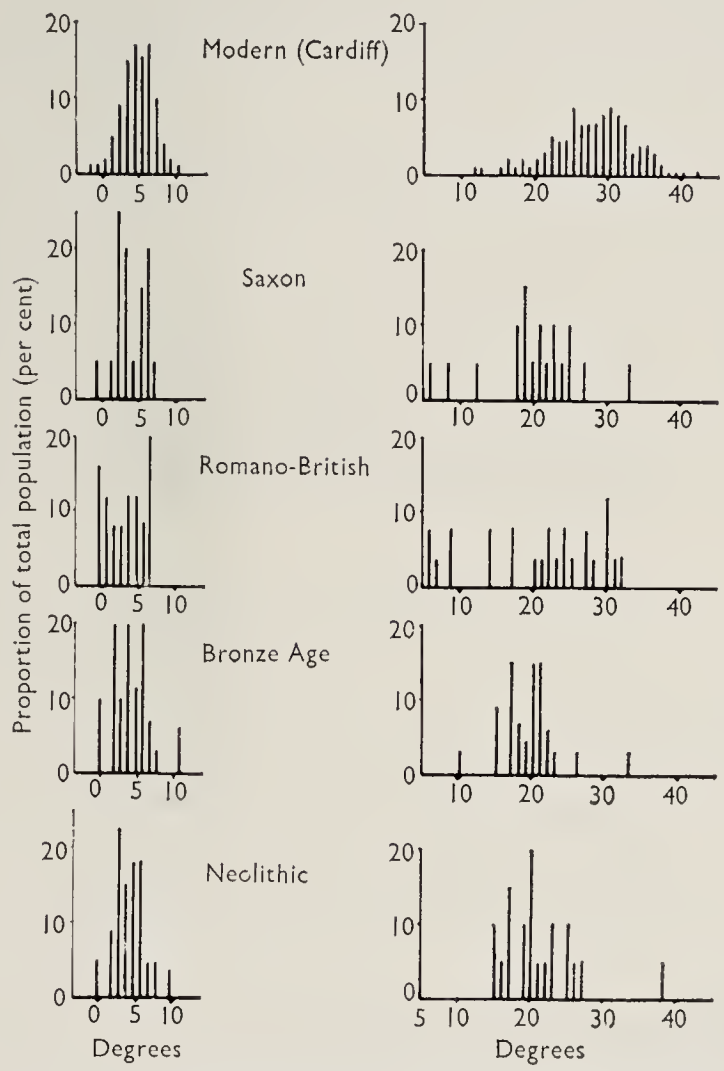

Fig. 7.—Comparison of angle ANB (*left*) and the Frankfurt-mandibular-plane angle (*right*) in modern and early populations (*see text*).

tends to reduce the severity of a malocclusion. In fact Class II, division 1 occlusions tend to grind themselves into more normal incisor relation as the crowns become shortened. Overcrowding also is reduced by interproximal wear so there seemed to be little point in comparing Neolithic with modern malocclusions except possibly in type, certainly not in severity. It might be possible, though, to study dental base relationship by

may be seen in some human populations. Each immigrant wave into Britain would come from a little way or a longer way along the cline (and in this context it is necessary to postulate a cultural as well as a morphological cline). If the separation was small, genetic mixing would probably ensue and if large it would not. Mixing of morphologically widely distinct types would be unlikely to occur.

Thus far I have had to generalize, insufficient intact skulls being available to assess population characteristics even in the crudest way. In the hope of remedying this deficiency I made a study of occlusal characteristics of some early skulls: the earliest group available for study and which are sufficiently well preserved to be orthodontically meaningful are Neolithic. Now all these skulls show extreme attrition of the teeth. Begg (1954) has shown that attrition makes more space available for the teeth and also that it

measuring the angles ANB and the Frankfurt-mandibular-plane angle, both of which could be measured directly on the skulls and both of which we make considerable use of clinically. By kindness of the Directors I was able to examine and measure skulls in the various collections now housed in the Anthropology Department of the British Museum (Natural History) and in the Department of Anthropology at Cambridge. A modified protractor was used for the Frankfurt-mandibular-plane angle and a simple instrument (*Fig.* 6) made to measure directly the angle ANB to an accuracy of less than 1 degree. Unfortunately out of several hundred skulls examined so many were incomplete or distorted that only 104 were suitable for measurement, of these 23 were Neolithic, 32 Bronze Age, 29 Romano-British, and a sample of 20 Anglo-Saxon skulls were included. We know now that Neolithic man lived in breeding isolates or demes, and differed

morphologically in different parts of the British Isles. These numbers seemed so pitifully small that I abandoned the original study. I recently re-examined the results of the survey and by the kindness of Mr. M. Harkness I was able to add a much larger sample of Cardiff schoolgirls examined radiographically (240 individuals). The results are shown in *Fig.* 7. In order to compensate for the varying numbers of individuals I have expressed these as percentages of the total sample. There is no appreciable difference in the angle ANB between any of the samples except Romano-British. In the case of the Frankfurt-mandibular-plane angle there seems to be a tendency to increase in the Cardiff sample but this may well be due to differences between direct and radiographic assessment; as with the former angle the Romano-British sample stands out. Historically this is easy to account for as the Roman armies were of many races and some of the skulls must have represented the indigenous population. What is of interest is that the spread of variation of Neolithic man could be guessed from the histograms to be only slightly narrower than that of the modern sample. I repeat that the sample is too small for firm conclusions to be drawn but I am hopeful that as additional material becomes available it will be possible to extend this study. Meanwhile can we do better with modern studies of malocclusion?

THE INCIDENCE OF MALOCCLUSION IN PRESENT POPULATIONS

One might assume that the incidence of malocclusion in living populations would be well documented, but to be of value in the present context surveys of the incidence and type, in different countries and in different racial groups must be based on identical criteria: ideally the study should be carried out by the same investigators or at least by different teams using the same carefully defined parameters. Unfortunately this has not yet been done so this discussion must be severely cramped. Nevertheless, certain rather tentative conclusions may be drawn from past studies, though these must clearly stand or fall according to the results of those yet to be carried out.

Two of the most closely comparable studies are those of Massler and Frankel (1951) on Caucasian children and Altemus (1959) on American Negro children. Their findings, shown in *Table IV*, were that 'ideal occlusion' was present in 3·7 per cent of Negroes and 2·9 per cent of Caucasians, whilst 'normal occlusion' was present in 12·8 per cent Negroes and 18·2 per cent of Caucasians, a result not at all in accordance with the preconceptions of most people.

Clinch (1951) examining the dentitions of Australian aboriginals, found ideal occlusion in 1·85 per cent of those living in civilized conditions compared with 6·77 per cent of those living a primitive existence, a difference which must be valid as the same standards were used by the same observer: this could well be accounted for by the differences in interproximal wear referred to earlier.

I quote these four sets of observations to indicate the way in which we must draw our conclusions. The first and second are valid comparisons, as are the third and fourth but it would be very unwise to compare the American and Australian studies. A sample of modern surveys is summarized in *Table IV*, from which it is clear that we are still a long way from establishing a universal standard.

Table IV.—Studies of Malocclusion

Investigator		Angle's Classification				Population
		Class I	Class II, division 1	Class II, division 2	Class III	
Ast and Carlos (1965)	Mild	69·8	8·8	4·9	1·5	American white children
	Severe	14·0	6·7	2·6	1·4	
Massler and Frankel (1951)		50·07	16·68	2·71	9·43	American white children
Altemus (1959)		66·4	10·55	1·58	4·99	American Negro children
Telle (1951)		33	22		7·3	Norwegian children
Newman (1952)		36	—		5·4	Adult Eskimo
Gardiner (1955)		88·5	10·9		0·6	English children

The only firm fact that emerges is that ideal occlusion is relatively uncommon in modern man, of whatever race. Where the surveys are comparable they indicate that there is a difference between populations in the relative proportions of the three classes of malocclusion, Class II being commoner in Caucasians than Negroes and Class II being virtually unknown in Eskimoes (Newman, 1952).

Lundström and Lysell (1953) examined the skulls from a Medieval graveyard in Sweden and compared their findings with Seipel's (1946) figures for modern Swedes. Both groups were probably almost purely Nordic and therefore comparable. They found that the incidence of Class II and Class III malocclusions were similar in both groups but that the severity was on the whole greater in the modern group. Not surprisingly, they found a difference of dental arch width of 2 mm. in the premolar region and 4 mm. in the molar region. In view of the results of the dietary experiments referred to below this must be accounted for by a population change rather than an environmental factor.

Summarizing these surveys we are again forced to the conclusion that the condition we call malocclusion is, and has been for many generations past, an almost universal state in *Homo sapiens*, that its character may vary from race to race, and that we do not have to resort to racial admixture to account for it. I suggest that the results of Stockard's (1941) breeding experiments with dogs do not apply to the aetiology of human malocclusion.

DIETARY ADAPTATION

Occlusal wear in carnivorous animals is very slight: their dentition is adapted for an eating pattern which consists of tearing off pieces of meat with their canines and passing the piece back to the saw-edged cheek teeth which repeatedly pierce it with a chopping movement after which it is swallowed whole. Herbivorous animals pass the food rapidly to the flattened cheek teeth which macerate it into pulp before swallowing it. Consequently these teeth form a more or less flat grinding platform and in the true herbivores they are fitted closely together to give the appearance of a continuous unit in contrast with separate spaced molars and premolars of the carnivore. Their posterior teeth are adapted to the inevitable wear by various means such as elongated crowns or continuous formation.

Precisely what it was that the early hominids ate we do not know, but the chewing of meat and fruit does not cause molar wear, whereas a vegetable diet does and most of the individuals which I have mentioned from *Ramapithecus* to Roman times showed considerable wear. Microscopic examination of the scratches on the teeth gives a good idea of the size of the particles which made them and these were undoubtedly larger than the siliceous inclusions of plants and were in fact either sand in the soil adhering to roots, etc., or produced from the stones used in grinding grain. As the latter practice did not commence until the Neolithic period, it follows that throughout a large part of Man's evolution he ate a lot of fibrous vegetable matter. As most of us know to our discomfort these fibres tend to pack between the teeth if the contacts are at all loose; such food-packing would have serious consequences and interproximal pressure would have a selective advantage. It is not surprising that even as early as *Australopithecus robustus* normal variations in jaw and tooth size would produce a proportion of individuals with a minor and quite harmless degree of overcrowding, even though they showed a normal amount of interproximal wear. In Neolithic and Bronze Age times there were individuals who seem to have departed from the usual diet in some way and show relatively little wear with consequently a higher degree of incisor crowding.

THE GENETIC BACKGROUND

Overcrowding

Whatever the immediate cause of malocclusion the underlying factors must be genetically determined and influenced little by any factor in the environment other than occlusal wear. Nevertheless one frequently meets references in the dental literature indicating or implying that our present soft diet is an influence still to be reckoned with in so far as it retards muscle and bone growth. As recently as 1964 Oppenheimer explained the overcrowding already referred to in the teeth of *Australopithecus* by the fact that he had started to use tools and therefore used his jaws less. He states that ' in civilized man the teeth are crowded because of severely reduced function ' and in support quotes the animal experiments of Pratt, (1943), Thoma (1938), Washburn (1946, 1947), Horowitz and Shapiro (1951) and Avis (1961). He is then faced with the necessity of explaining the reduction of overcrowding in later hominids. This is done ingeniously by suggesting that irregular teeth would produce a selective disadvantage in mimetic communication and would reduce the chances of mating in the newly adopted face-to-face sexual position. He concludes by stating flatly that ' the only plausible explanation for the crowded dentition of Australopithecines is a substitution of tools and weapons for teeth and jaws '.

Even more recently, Moore, Lavelle, and Spence (1968) observe that ' although the presumptive evidence is strong that the observed reduction in the jaws [in evolution] has in large part been a direct result of the diminution of forces produced

by the masticatory muscles on the osteogenetic tissues of the facial skeleton the possibility that genetic change . . . has been involved cannot be excluded.'

Finally, Campbell (1967) in his excellent and authoritative work, *Human Evolution*, makes this statement: 'Experiments on animals have demonstrated that in ontogeny the final size of the mandible and masticatory muscles depends on the amount of use the masticatory apparatus is put to during growth—an example of developmental homeostasis. On the other hand the size of the teeth is not affected in this way by environmental influence but is under more or less direct genetic control. The crowns of the teeth are of course subject to wear but the length and breadth of the crown is not modified unless the tooth is damaged.

'There is always a delay between a change of selection pressure and the appropriate genetic (evolutionary) modification, a delay beautifully demonstrated in the fossilized dentition of *Australopithecus robustus* in which marked tooth crowding is characteristic. This phenomenon indicates that the jaws did not grow to the size for which the teeth had evolved. The need for a heavy jaw was lost, but the teeth had not yet been reduced; the phenotype had made some adjustment to altered environmental conditions but the genotype as yet had not. Tooth crowding is seen in modern man for similar reasons.'

The force and authority of such statements demands a close investigation of the facts: few would quarrel with the statement that the size of the teeth is genetically determined. However, it has been shown on a number of occasions that wear *does* in fact reduce the mesiodistal diameter of the teeth, perhaps most convincingly by Begg (1954) who showed that on the rough diet of the stone-age Australian aboriginals there was, in addition to occlusal wear, appreciable interproximal wear. Comparing the mesiodistal diameters of worn and unworn teeth from a large collection (from 16 to 32 of any one kind) he showed that the sum of the diameters of all the teeth on one side of the mandible averaged 62·06 mm. *before* wear and 56·78 mm. *after* wear. On the whole of the mandibular arch, therefore, the loss of tooth diameter was 10·56 mm. These measurements were made on jaws in which the third molar had not yet erupted and the wear would be progressively greater as the teeth are worn below the level of the contact point. This work has been amply corroborated by Lysell (1958) and Goose (1962).

We regard ideal occlusion in man as implying contact between all teeth. In any human population with varying tooth size some members will have ample space and some will be on the verge of overcrowding. Failure to wear the teeth interproximally will obviously increase the proportion of the population in which dental overcrowding occurs.

Failure to distinguish between dental arch size and mandibular size seems to have been the source of this widespread confusion. We are now in a position to appreciate that dental base size is only one of several factors affecting dental arch size.

Differences in jaw size between animals on hard and soft diets have been investigated by Watt and Williams (1951) and Moore (1965, 1967) and these studies showed quite conclusively that the overall size and density of the mandible was very significantly reduced when animals were fed from a very early age on a semiliquid diet as opposed to a hard diet. Only Watt and Williams (1951) measured the dental arches and then only in width. They showed that in rats the width of the maxillary arch was reduced by 0·79 per cent in their soft-diet animals. One might recall that the difference in diet between the two carefully controlled sets of animals in these experiments was that in one case they were fed on hard rusks and in the other the rusks were pulverized to a flour and mixed with water to form a slurry. When an arch-width reduction of under 1 per cent is compared with a reduction of arch perimeter of the order of 8 per cent shown by Begg to be due to tooth wear the results of the dietary experiments are seen in their true perspective, and the conclusions quoted above must be fallacious.

Goose (1962) and Moore and others (1968) have shown a reduction in jaw size between Neolithic times and the nineteenth century. They are not dogmatic about the causes of this reduction. Drummond and Wilbraham (1957) show that whilst the nutritional value of the food in the last five centuries has varied greatly, there is nothing in their work which indicates to me a very great difference in its physical consistency.

It is always difficult to separate and distinguish the effects of environment from those of genetic constitution where malocclusion is concerned and where human experiment is impossible, but custom-controlled diets in different social groups would form a basis for further investigation. Is malocclusion more prevalent, for instance, in the Masai tribe whose diet consists of milk and blood than in similar tribes who eat food which must be chewed?

On evidence at present available I suggest that the consistency of the diet has no observable effect on jaw size or tooth crowding either developmentally or phylogenetically if it does not result in actual reduction of tooth size by wear; the cause of overcrowding must primarily be genetic.

Racial Effects

Man is a polytypic species, that is one consisting of several subspecies and races. These different races arose through the isolation of groups by

geographic or social barriers which prevented interbreeding with other groups (Cole, 1965). To qualify as a subspecies at least 75 per cent of the individuals of a group must be taxonomically different from another group with which it is compared. If we were to classify man according to this rule (which in fact is not done) we should be left with three subspecies: Caucasoids, Mongoloids, and Negroids. Within these subspecies are groups, races, and subraces, everywhere grading into one another forming clines between neighbouring populations.

Man has 23 pairs of chromosomes and the number of possible combinations of their genes is about 16 million but in practice an individual is believed to be the product of about 44,000 pairs of genes. Of these, some 90 per cent are common to everyone; of the remaining 5000 at least half must be allowed for sexual and racial differences and only 2500 or 3–5 per cent of the whole remain to account for individual variation (Cole, 1965).

Social prejudices form much more of a barrier to racial mixture than we realize, though this may change in the future. When the fate of small immigrant groups, such as the Huguenots, the Lancastrians in Finland, and the Welsh in South America, is examined it is found that they die out altogether or they remain as more or less intact minorities; rarely are they absorbed into the resident population. If they are sufficiently numerous they may, of course, displace the residents. Recent investigations indicate that the Basques possess blood-group frequencies quite distinct from any in Europe. This fact, their unique language and their skull morphology indicate strongly that they represent more or less unchanged descendants from the early Neolithic population of Europe. Despite the fact that they have lived for some thousand of years in the midst of several distinct and different racial types; their own gene pool, as shown by the relative incidence of blood-group B and of the Rhesus factor, has remained distinct.

Looked at in this light the probability seems overwhelming that the changes in jaw form and cephalic index referred to later in the inhabitants of Britain must be due to successive replacements or substitution of the population rather than to dilution or evolution; the spread of racial genes is, in fact, a slower process than would at first appear due to the invisible barrier of cultural segregation.

If we examine, at least superficially, what we know of the population changes in Britain we must start with the Swanscombe skull fragments, which are dated in the Mindel-Riss or Second interglacial and which ' deviate from the anatomically modern morphological pattern and instead are allied with the early Neanderthal peoples ' (Howell, 1960). The race was wiped out of Britain north of the Thames by the next glaciation and died away in Europe. Of their successors in the Upper Paleolithic little is known except from the stone implements they left behind. From these, successive cultures can be identified which do not merge into each other: they indicate successive *replacements* of population without any sign of transition and I suggest that these early men did not mix their genes any more than they mixed their arrowheads.

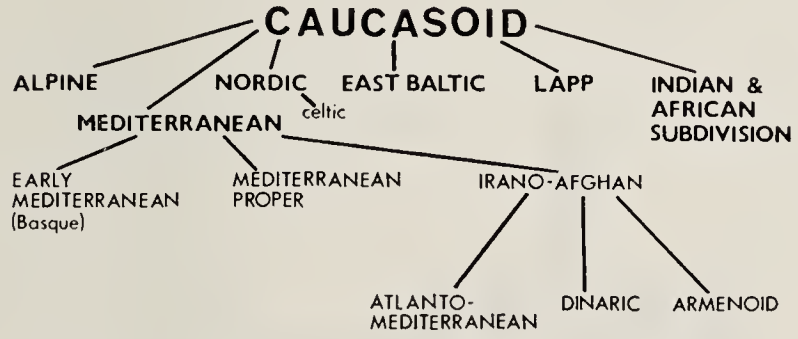

Fig. 8.—Subdivisions of the Caucasoid race.

Neolithic man, dolichocephalic and practising agriculture, left us not only his weapons but enough skeletal remains to enable us to make a fair assessment of his occlusion. His successors in the Bronze Age were rather less considerate to the anthropologist as they practised cremation to an increasing extent. From South-west Germany the brachycephalic iron-age peoples expanded through Belgium and France to the British Isles. Their descendants remain with us today as Celtic types in Ireland and in the Scottish Highlands, though they formed a much larger proportion of the English population as late as 1666, judging by the frequency of their remains among the plague-pit skeletons. As cranial types they were more variable than the earlier inhabitants.

At this stage it is necessary to look back at the Caucasian subspecies—the only subspecies which could possibly have contributed genetically to the Briton of today. Of all the Caucasoid subgroups I think it unlikely that Britain would have been affected by the Franco-Afghan, East Baltic, Lapp, African, or Indian. Slight influence of the brachycephalic Alpine subgroup may have been felt but the really important constituents are the Mediterranean and the Nordic (*Fig.* 8).

To quote Cole (1965), ' the differences between Nordics and Mediterraneans . . . are mainly in size and pigmentation. Compared with the Mediterranean the typical Nordic has a longer, narrower face, more prominent brow-ridges, a more sloping forehead, a longer, higher, and narrower nose, and a more pronounced chin. *The bones of a small Nordic are often indistinguishable from those of a large Mediterranean* ' [italics mine].

From the west Baltic area waves of Nordic people spread to France and Germany; in Britain successive waves of Angles, Saxons, Jutes, Danes, and Norsemen invaded the country from

the third to the ninth centuries, followed by the Norman Conquest, the Normans themselves being predominantly Nordic.

As the main constituent of our population is Nordic, as the Mediterranean component is similar skeletally, and as the earlier types were either displaced entirely or relegated to the mountainous areas of Wales and Scotland, the suggestion that our malocclusions stem from

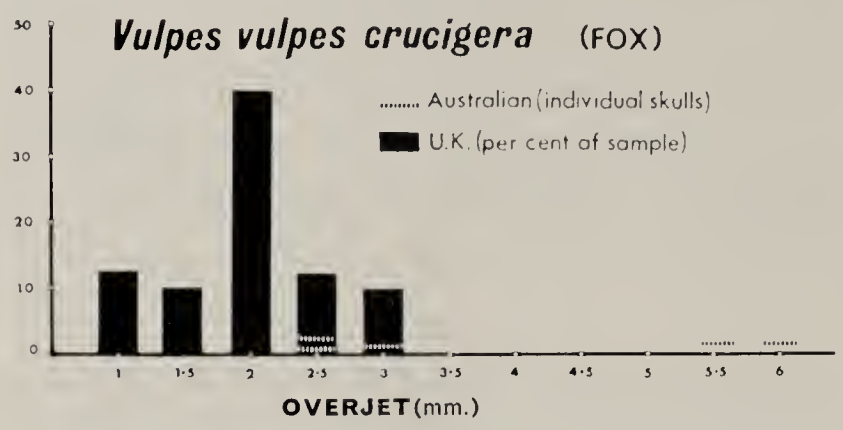

Fig. 9.—Comparison of overjet in five Australian fox skulls compared with a sample of 29 British specimens of the same subspecies.

the admixture of widely different racial types is scarcely tenable. The addition of the Mediterranean to the Nordic types would simply have the effect of increasing the variability or extending the range of such factors as tooth size, at one end of the scale, if indeed, any such real differences existed.

Variation

A local interbreeding population is known as a *deme*, defined by Mayr (1963) as a group of individuals so situated that any two of them have equal probability of mating with each other and producing offspring. At any point in time a deme is in very accurate balance with its environment; when the environment changes only slightly, the deme changes too, simply by a process of selection within the existing variation and without the introduction of any new genetic material. In short, the process of selection trims off one end of a genetic variable and allows the other end to develop. If the numbers of individuals in the deme is being reduced, some aspect of the environment, in the widest sense, must have been particularly severe and selection will be rigorous in eliminating all but those forms best able to survive. Consequently there will be little range of variation at such times and the population will be reduced to smaller numbers than the area could normally accommodate. When conditions become more favourable again the numbers will rapidly rise until they attain the level at which reproduction is balanced by elimination; meanwhile selection will have been less stringent than usual so that the population will have become more variable. The period of rapid increase in numbers thus provides a special opportunity for genetic recombinations to take place, many of which would very seldom be realized in a stable population. The great majority of these will be unfavourable and would never survive in normal conditions (Ford, 1967).

Instances of this may be seen in the Norwegian lemming which is subject to well-known cyclic fluctuations in numbers and in which those animals found in years of rarity are of a relatively constant colour whereas those of glut years are very variable.

Dental abnormalities have been observed to increase in species which have been introduced into alien lands and have there thrived and multiplied. Colyer (1948) observed this in the Green Monkey, *Cercopithecus aethiops sabeus*, introduced from West Africa to St. Kitts.

It has been reported in hedgehogs, *Erinaceus europeus*, introduced into New Zealand and appears to be the case in the fox, *Vulpes vulpes*, introduced into Australia (*Fig.* 9). Ford (1967) quotes a colony of the Marsh Fritillary butterfly, *Euphydryas aurinia*, which was observed over nineteen years. During this period there occurred a great increase in numbers between 1920 and 1925 which followed a slow decline between 1897 and 1913, the precise cause being unknown. Ford's own words are apposite to my own theme —' the amount of variation was small . . . while the species was becoming scarce, and it may be said that a constant form existed at this time from which departures were infrequent. When the numbers rapidly increased, an extraordinary outburst of variation took place so that hardly two specimens were alike, while extreme departures from the normal form alike in colour, pattern, and shape were common. A high proportion of these were deformed in various ways and some could hardly fly. When the rapid increase had ceased such abnormalities practically disappeared and the colony settled down once more to a comparatively uniform type.'

Such instances could be multiplied greatly and the concept of increased variability in times of increase is fully accepted by zoologists. This change is not due to genetic segregation as a result of inbreeding when the deme was small since the variation does not occur until the numbers are rapidly increasing. Ford accepts that this interpretation is only partial; the fact is indisputable.

Man is increasing his biomass at a greater rate than any known species and this probably commenced at the time of the Neolithic Revolution (*Fig.* 10). The analogy between the situations discussed above and the rate and type of changes leading to modern malocclusions are too obvious to require description but it may be of value to note that as grain became more plentiful, bread became a more and more important part of the diet and although quern-ground flour produced an abrasive bread it did not require a particularly

good occlusion to masticate it. Clearly the selective disadvantage of malocclusion from the point of view of nutrition has been of little importance for some thousands of years and as long as the present conditions persist we and our successors in this society are likely to be presented with malocclusions which become more bizarre as time passes.

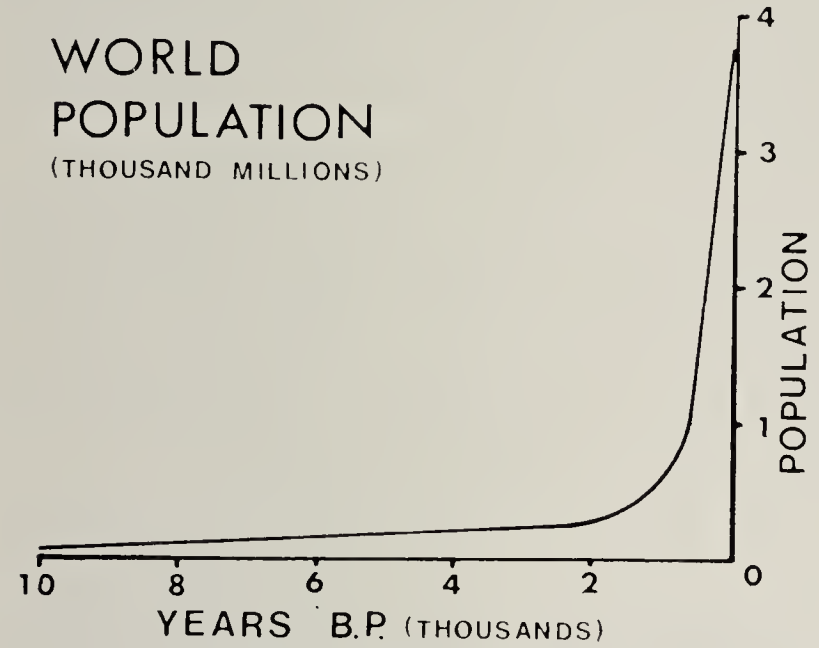

Fig. 10.—World population of *Homo sapiens.*

It may be argued that these examples taken from insects and rodents prove nothing as far as Man is concerned. As these changes take many generations it is clear that time is against any investigation. Fortunately there has been one change which has been sufficiently well documented to use as illustration.

The notion of genetic polymorphism is one of the fundamental concepts of population genetics. In general polymorphisms are classified as balanced or transient; a balanced polymorphism is one maintained by a selective advantage of the heterozygote. This can arise in many ways which I will not attempt to discuss here. A transient polymorphism is one in which the balance of variation is not maintained by selection. It too, can arise in a number of ways: by admixture of populations, during replacement of an allele by a newly favoured form, by a change of selection pressures from those following balance to one favouring one of the homozygous forms, or lastly to a change from selection favouring balance to effectively neutral selective forces (Workman, 1968). Thus under some circumstances the transient polymorphisms can be at loci at which the genotypes are in approximately Hardy-Weimberg proportions because the selective pressures are roughly neutral. This I consider to be the present situation for the teeth of Man. I would instance in this case the position of the sickle-cell gene in the malaria belt. Red blood-cells in affected individuals contain a modified haemoglobin which is recognizable by the presence of cells in which the haemoglobin has shrunk into abnormal shapes including forms where it adheres to one side of the cell in the shape of a sickle. Such red blood-cells are inimicable to the reproduction of the malaria parasite. In the heterozygote the degree of anaemia is not usually fatal whereas malaria is, so on balance the condition is beneficial to the individual. In the homozygote the 'double-dose' of the gene

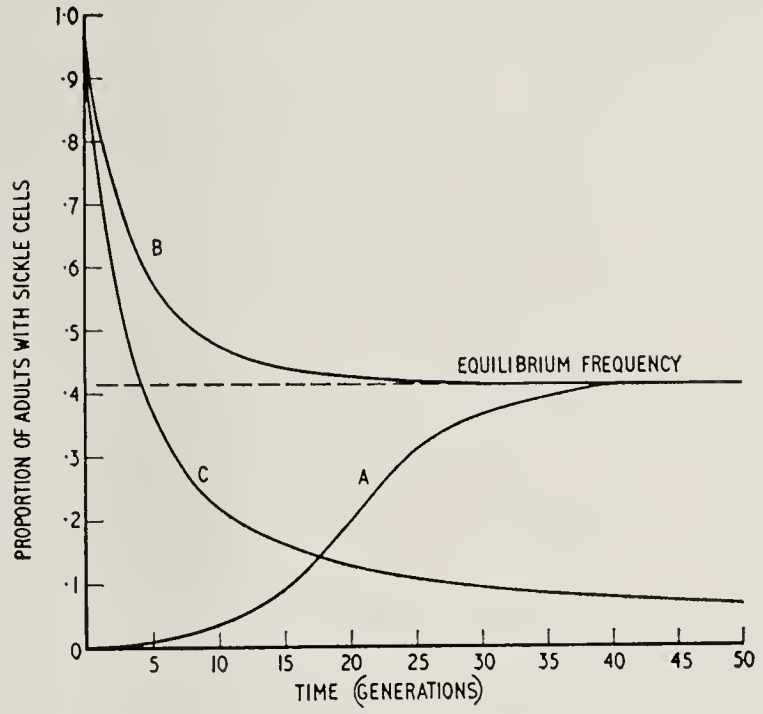

Fig. 11.—Rate of change of proportion of subjects carrying sickle cells. A, B, Heterozygote favoured. C, No heterozygous advantage (*after Allinson*, 1961).

usually produces an anaemia resulting in early death. In temperate countries the gene is almost unknown whereas in the tropical malarial belts its incidence rises in places to as high as 40 per cent. Mosquito control by insecticides, paraffin, etc., has reduced the incidence of malaria very greatly in these areas so that protection by the sickle-cell gene has become unnecessary, but, of course, the harmful effects of the anaemia remain: the result has been a dramatic fall in the incidence of the gene over the last 20 to 30 years (*Fig.* 11). This analogy is not as close as those given earlier as it concerns the *loss* of a gene due to removal of selection pressure but the mechanism is precisely the same as that by which genes or combinations of genes which produce variations in occlusion are *retained* instead of being eliminated.

Whilst discussing the genetic background it might be appropriate here to examine the suggestion that malocclusion did not occur as frequently in early Man because the necessary mutations have arisen since that time and also the corollary that, due to increase in radioactivity from X-rays and thermonuclear reactions our successors will have even more grotesque occlusions than we see today. In fact on the basis of mutation alone and using the common mutation frequency for a specified allele of once in a hundred thousand times Papazian (1967) has calculated that it will take 11,780 generations to increase from 0·1 per

cent to 0·2 per cent. Clearly random mutation will not play a part in the change of incidence of malocclusion which is significant in the context of a few thousand years.

IS MALOCCLUSION HARMFUL?

Whilst almost every type of malocclusion with which we are familiar can be found in living wild primates, in fossil Man and in Aboriginal Man, it is of a degree which in modern Man we would describe as ' mild '. From this it would be reasonable to assume that severe malocclusions must have had a selective disadvantage; that in some way they rendered the individual less fit, in the evolutionary sense, than his contemporaries and that such effects must have been felt before or during the reproductive phase. For reasons which I will discuss shortly it is unlikely that caries, periodontal disease, temporomandibular joint dysfunction, or aesthetics were among those effects. One can only assume, tentatively, that the dietary régime was so rigorous that reasonably good occlusion was necessary for adequate nutrition. Life under modern conditions makes this difficult to appreciate but at present no other explanation seems possible. Factors such as tooth size, jaw size, and jaw relationship are continuously variable and must therefore be polygenic in origin. In any population one would not expect to find the sudden appearance of, say, a severe Class II, division 1 malocclusion: the range of variability would have to increase gradually and this would be prevented by the selective factors already referred to. As soon as Man took to a sedentary existence in Neolithic times and began to practise a division of labour in which some individuals were food gatherers or harvesters whilst others stayed at home to make stone weapons and later to practise pottery and metalwork the brakes were off as far as occlusal variability was concerned. Malocclusion had ceased for ever to be a disadvantage dietetically and in evolution.

Is malocclusion a disadvantage to modern Man? Possible ill effects can be grouped under the following headings:—

1. Increased liability to caries.
2. Increased liability to periodontal disease.
3. Increased liability to temporomandibular joint disease.
4. Aesthetic disadvantages.
5. Difficulties of speech.

Malocclusion and Caries

The majority of investigators concerned with the relationship between malocclusion and caries has been interested more in whether caries, through tooth loss, causes malocclusion, than in the reverse. Contrary to my expectations I have been quite unable to find a paper which, on an epidemiological basis is able to show any but the slightest causative effect of malocclusion on caries incidence. Jackson (1969) states that the caries experience in Class I and Class II malocclusions is no different from that of children with normal occlusion but he does find that there is a slight increase in caries experience associated with Class III malocclusions, though he thinks that this is more likely to be a genetic effect.

Presumably, irregularity, by changing the position of the contact points between the teeth, must influence the point of attack of caries but it does not affect the DMF rate for the individual.

Malocclusion and Periodontal Disease

A study of some 40 papers written between 1960 and 1968 on the relationship between malocclusion and periodontal disease is to say the least confusing. Broadly these papers can be divided into epidemiological studies, all of which show a very low correlation between the two conditions, and papers describing how to treat the latter by eliminating the former.

Unfortunately, with few exceptions such as that of Gould and Picton (1966), the epidemiological studies have been carried out on children and an assessment made of the gingival condition. Again unfortunately, I have been unable to find a longitudinal study showing whether or not childhood gingivitis is necessarily progressive. Miller and Hobson (1961) showed a positive, though not very convincing correlation between malocclusion and poor gingival conditions (*Table V*). They point out that as far as Class III is concerned the numbers are too low to permit comparison. In the remaining classes of occlusion the differences in incidence of gingival disease differed less than between boys and girls in the same age-group. Wade (1966) found that the effect of malocclusion was an insignificant factor in the production of gingivitis compared with oral hygiene in Iraqi children. Beagrie and James (1962) found that in young adults there was no positive correlation between disease score and posterior tooth irregularity and in fact rotated teeth were less prone to periodontal disease than normal teeth, though they say that this may be a sampling effect as there were only 12 teeth with a rotation of more than 45 degrees.

Rosenzweig and Molk (1963) found a positive association between the two conditions in Jewish and Arab children and make the pithy and succinct statement that ' It is possible that a particular type of malocclusion is more conducive to gingivitis than others '. It seems strange that Gould and Picton (1966), surveying adults, could find no readily demonstrable correlation.

I think it would be fair to summarize the present opinion by saying that malocclusion may be responsible for aggravation rather than causation of periodontal disease, that there are rather obvious exceptions to this, such as the single labially occluding lower incisor, and that

excluding such exceptions malocclusion is of very small importance compared with oral hygiene. One might add that all such factors without exception disappear with occlusal wear or, presumably, with occlusal grinding.

Malocclusion and the Temporomandibular Joint

True arthritis of the temporomandibular joint is a rare condition: much more common is that collection of signs and symptoms involving clicking of the joint and sometimes pain, frequently on opening. It is usually, but not always unilateral and the joint itself exhibits no pathological changes. It is more common in the female than the male and occurs usually between 20 and 40 years of age (Franks, 1964). Treatment was largely empirical until Hankey (1956) and Ballard (1956) assembled the facts and showed that the pain was associated with muscular spasm, that emotional factors played a part in causing this, and that mandibular displacement due to cuspal interference was the underlying cause. This concept remains unchanged today (Ware and Taylor, 1968). Various clinicians direct their attacks at different points along the chain. Those who play down the role of mandibular deviation justify this by pointing out that there are far more people with deviation than with joint conditions. This does not change the fundamental truth of the concept outlined above.

We shall never know whether or not primitive Man suffered from this condition as joint changes are rarely found. As he always wore off his cusps mandibular deviation could not exist except in childhood so it is unlikely that he did in fact do so.

Orthodontic treatment cannot be regarded as complete until mandibular deviation has been totally eliminated if this condition is to be prevented.

Aesthetic Considerations

Your President has dealt so thoroughly with this topic that I have little to add (Wood, 1969). Standards of beauty do vary not only from place to place but from time to time. High degrees of prognathism or ' bimaxillary protrusion ' are acceptable and even desirable in some African tribes and in parts of China and Mongolia, though similar dentitions in Western Europeans would at present cause their owners considerable unhappiness. In the United States orthodontists receive many requests from Caucasian parents to reduce this condition in their children because they wish them to look as unlike Negroes as possible. This is an example of racial non-acceptance: certain racial characteristics such as prognathism, Mongoloid eyes, steatopygia, curly (or straight) hair, patterns of breast development, and so on, form a pattern unique to a particular race. Variation of these characters within certain limits is acceptable but beyond those limits an individual may find social acceptance or marriage a difficult problem in the Society in which circumstance orders him to exist.

Table V.—Occlusion Related to Gingival Conditions at Age 12 Years (from Miller and Hobson)

Occlusion	Gingival Condition			No. of Children
	Good (per cent)	Fair (per cent)	Poor (per cent)	
Normal	27	48	25	427
I	12	53	35	161
II	16	52	32	179
III	22	33	45	9

There is good reason to suppose that, within these acceptable limits, there is what might be called fashion in beauty. Hair styles, male and female, undergo cyclic changes. A glance at the film stars of the 1920's and 1930's shows a marked difference from those of today. Until recently I had not come across an instance in which dental irregularity was regarded as actually desirable in European Society. I must admit some surprise in reading Nancy Mitford's (1966) account of Louis XIV's description of the 10-year-old Marie-Adélaïde: ' It was love at first sight. I have never seen a prettier figure; she is dressed fit to be painted. Her eyes are bright and beautiful, her complexion perfect. She has masses of black hair, luscious red lips; white, most irregular teeth, pretty hands, etc. ' Admittedly, this is not usual but it does underline the fact that incisor irregularity need not necessarily be a cause of unhappiness to its possessor.

It is a fact that some emotionally disturbed people do place the blame for their failure to fit into society upon some physical defect such as the teeth when in fact there is some inadequacy of personality which is to blame. Conversely, I believe it is a fact that children with such handicaps as cleft lip and palate are more prone to delinquency than other children, and there is no doubt that children with such handicaps as severe Class II, division 1 malocclusions, especially

when associated with short upper lips, are made extremely unhappy at school.

The whole problem of the psychological effects of malocclusion has received but little attention in the past. One thing is certain—it is useless to assess the aesthetically handicapping effect of the malocclusion without relating it to the personality of the patient.

As the number and ability of orthodontists increases in a sophisticated society so does the demand for incisor alinement. At one end of the age range we have orthodontists correcting minor incisor displacements and at the other end prosthetists incorporating the same irregularities in dentures to ' make them look natural '.

Malocclusion and Speech

Hopkin and McEwen (1956) showed by means of a palatographic technique how tongue position was changed when making certain consonants, with a change in the position of the incisor teeth. Many observers have referred to the association between interdental sigmatism and anterior open bite. I have yet to see any reference to the normal ' s ' sound being produced with the tongue in the interdental position, though this is in fact quite common.

It is generally accepted that the position of the teeth does not affect the vowel sounds but only the consonants made in the anterior part of the mouth. It is less generally realized that the same sound may be produced in more than one way. If this were not so all children with malocclusion would have speech defects. In fact the very great majority speak quite clearly; moreover, when their occlusions are restored to normal they are capable, without difficulty, of adapting their speech to the new positions of the teeth. Similarly the provision of dentures or bulky orthodontic appliances creates an obstacle only for a very few days.

It is generally felt among speech therapists that patients with poor ability to orientate their tongue position may in fact find the task of speech easier if the incisor teeth are alined. This is a reasonable supposition, though unsupported, as far as I am aware, by any statistical proof.

Certainly there is no evidence that malocclusion as such is a general causative factor in speech disability.

CONCLUSION

In 1962 the World Health Organization defined a malocclusion as requiring treatment ' if the disfigurement or functional effect is, or is likely to be, an obstacle to the patient's physical or emotional well-being.'

Salzmann (1968) reporting on the committee set up by the American Dental Association to assess the relative needs of individuals for orthodontic treatment under the proposed Health Schemes in the United States describes a ' points ' system to determine the degree of handicap. This system is heavily biased in favour of such physical ' handicaps ' as incorrect cuspal relationship, speech defects, and the like, and seems to pay relatively little regard to facial aesthetics. In my opinion it would be quite impossible to support on a scientific basis many of the committee's assumptions regarding what in fact constitutes a handicap.

Comparable attempts to relate the degree of abnormality to the need for treatment or for financial aid have been made in the Scandinavian countries. The World Health Organization tackles the problem from the other end by stating that ' the prevalence of malocclusion in a Caucasian population group assessed by epidemiological methods should approximate to one out of four children needing treatment '. Presumably this figure is based on surveys carried out by orthodontists and reported in the literature. Such estimates are, of course, arbitrary and none so far have been based on objective criteria regarding the effects of malocclusion.

The evidence I have presented suggests that ' ideal occlusion ' as we term it is a more or less fortuitous situation occurring somewhere in a broad band of variation which we refer to as ' normal '; the precise width of this band has yet to be determined by investigation of the effects of variation in tooth position on dental disease and social adaptation. It may be a wider band than we had previously supposed. Further, ' ideal occlusion ' with full cuspal interdigitation is an unnatural condition in Man; it has been seen only in the last few hundred years, as prior to this the cusps were worn off as the teeth erupted so it did not even exist as a transient state.

In Man adult occlusion as produced by the process of evolution is one in which the cusps are worn off the cheek teeth, the overbite is completely eliminated by wear and in which there has been a loss of tooth substance by interproximal wear equivalent roughly to a premolar width in each quadrant.

Many orthodontists accept that a proportion of the present population cannot accommodate in their mouths a full complement of teeth and that in these cases it is necessary to imitate the effects of this wear by removing a premolar on each side of both dental arches. So far there seems to have been no general attempt to imitate the other part of the situation by grinding off the cusps, although I did hear of an eminent dental surgeon incorporating pumice powder in his home-made bread for this purpose!

I have suggested that Man's dental evolution has been characterized by tight contact points or even mild overcrowding, loose contacts or interdental spacing being a selective disadvantage, and that the present incidence of malocclusion is purely the result of vastly increased variation

associated with the human population explosion of the last hundred generations combined with lack of selection pressure and lack of tooth wear.

A great many questions are still unanswered: so far no satisfactory explanation has been offered of the relative reduction in palate size in modern populations. We need very much more information on the effect of malocclusion on the physical and psychological health of the individual. We need to know what is normal in the sense of knowing what type of occlusion with or without cusps we should be trying to produce by orthodontic treatment. We know very little of the world distribution of malocclusion: that which we do know is bedevilled by the fact that we are all using different yardsticks. Our knowledge of aetiology and of methods of treatment has expanded greatly over the last few decades: certainly we must continue our efforts in this direction but I think also that we have reached a point where we should look around and take stock of our position—look a little more deeply into the natural history of malocclusion.

Acknowledgements

My thanks are due to the Directors of the Anthropology Departments at the British Museum (Natural History) and the Duckworth Laboratory, Cambridge, for permission to use the material in their departments and to Mr. D. R. Brothwell and Miss Rosemary Powers of the former department for much helpful advice. The animal skull studies were carried out at the Zoology Department of the British Museum (Natural History) and the Odontological Museum of the Royal College of Surgeons, and I am indebted to the Curators of these two departments. Professor A. E. W. Miles has been ready with his advice and guidance. To him and to Mr. M. Harkness who made available the results of his Cardiff Survey I am grateful. Finally I would like to thank Mr. B. G. Campbell, Dr. J. R. E. Mills, Professor J. Miller, Professor Tobias, and Mr. A. C. Allinson for the use of illustrations and all those people too numerous to mention who have guided and advised me in the preparation of this paper.

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MODIFIED STRAP OR SELF-STRAIGHTENING SPRING TO RETROCLINE INCISOR TEETH

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This removable appliance uses the well-known principle of a self-straightening spring to retrocline incisor teeth. The spring is carried on a labial arch incorporating two loops at right-angles to the length of the arch. The spring is attached to one loop, and is free-sliding through the other.

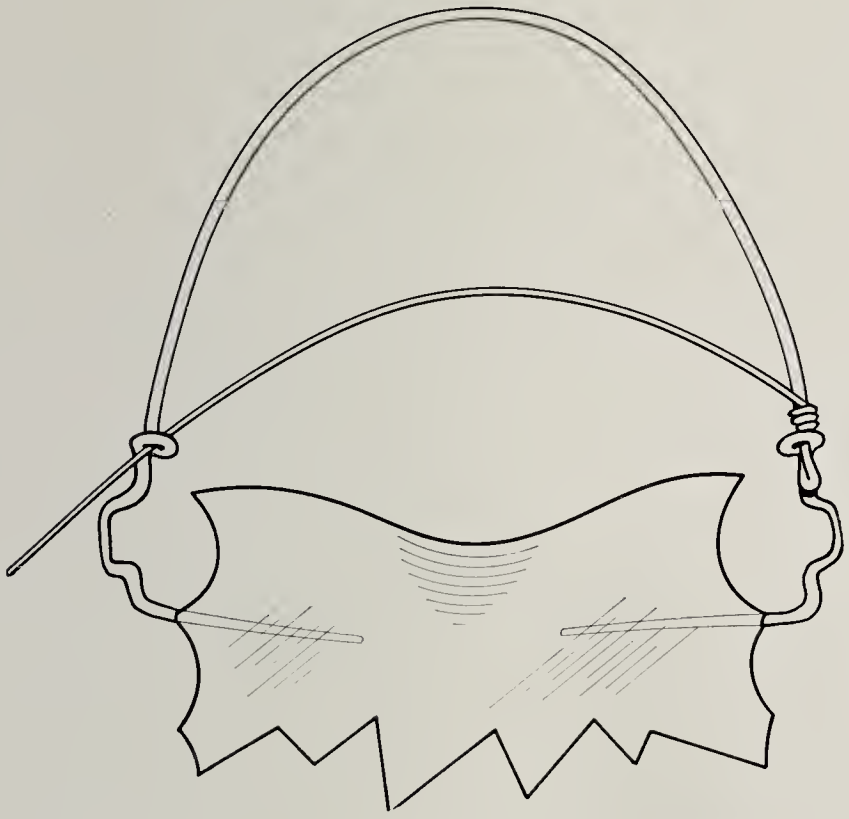


Fig. 1.—Strap spring carried in loops anterior to U-loops.

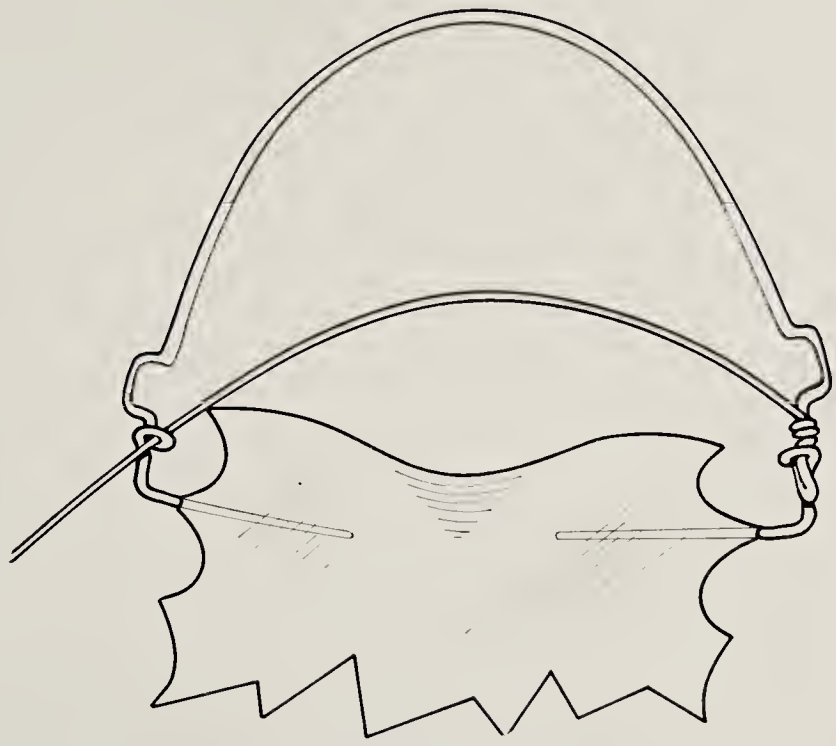


Fig. 2.—Strap spring carried in loops posterior to U-loops.

CONSTRUCTION

Assuming that upper incisor teeth are to be retroclined and that canine teeth are already retracted, a labial arch is designed using 0·7-mm. hard round stainless-steel wire. The distal ends of the arch may cross to the palatal side of the dental arch at any point distal to the canine teeth, or be soldered to the bridge of the cribs used for retention of the appliance. The arch should have inverted U-loops placed over the canine teeth. The loops carrying the spring are situated immediately anterior to the U-loops and are on the lower aspect of the arch (*Fig.* 1).

The first step in forming the arch is to make a loop of 1·0-mm. internal diameter in line with the length of the wire. The ends of the wire are then turned through 90°, so that when the arch is placed against the teeth the loop is at right-angles to the arch. A second loop is formed, and again turned through 90°. Each loop rests immediately anterior to the respective canine tooth. U-loops are then formed distal to the small loops in the usual way, and the posterior

Demonstration at the Country Meeting held in Leeds on 11 April, 1969.

ends attached to the appliance as suggested above.

It is important to ensure that the small loops are formed slightly on the inside of the arch rather than directly beneath, so that they do not abrade the inside of the lips and cheeks. They usually fit neatly in towards the space mesial to the canine teeth. The loops should be formed as

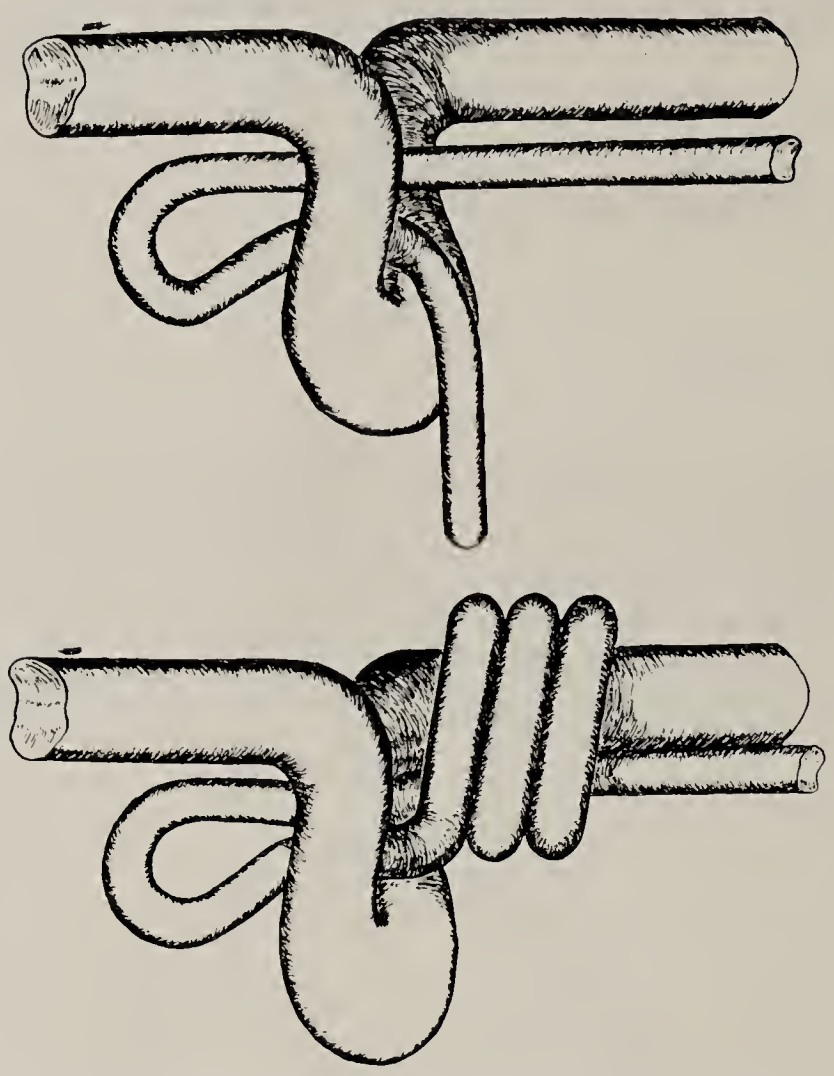


Fig. 3.—Method of attachment of strap spring into loops on the labial arch.

far apart as possible so that a long self-straightening spring can be used, as this reduces the flattening effect on the dental arch. To achieve a greater length of spring, the loops carrying it may be placed immediately posterior to the U-loops. In this alternative the loops are inclined towards the interdental space distal to the canine teeth (*Fig.* 2).

The self-straightening spring is attached in the following way. A 25-cm. length of 0·5-mm. hard round wire is taken and about 10 cm. of one end are turned over through 180° so that the short end lies against the length of wire. The long end is introduced into one loop from the posterior side, and the short end is also drawn through. The spring is then pulled into place so that the bend becomes tightly wedged into the loop. The short end is turned through 90° and given three turns around both arch and spring (*Fig.* 3).

The spring is now firmly fixed into the loop. The spring is then laid alongside the arch and the free end threaded into the second loop from the anterior side, and finished at the end with a small protective coil. The length of spring is about 2 mm. longer than the distance between the loops on the arch. As the spring is still a straight length of wire, it lies passively across the arch and is active when drawn up to the arch into its fitting position around the labial surfaces of the incisor teeth. This is the well-known self-straightening effect. The base of the appliance must of course be trimmed palatal to the upper incisor teeth.

If this appliance is used to retrocline lower incisor teeth the arch is inverted so that the spring is above the arch. A stainless-steel lingual bar is fitted to allow lingual movement of the lower incisor teeth.

Additional anchorage can be added by using an extra-oral arch fitted into tubes on the first molar cribs.

ADJUSTMENT

The force exerted by the spring can be adjusted by altering the passive curvature. The greater the curvature and the more parallel it is to the arch, the less force is produced. A spring 7 cm. long, actuated so that it is at rest 8 mm. on the palatal side of the arch exerts a force of approximately 100 g., which is distributed over the 4 incisor teeth, and each tooth therefore receives a force of approximately 25 g. The theoretical range of movement at the centre of the spring is 8 mm. when activated in this way.

As the teeth are retroclined, they move away from the labial arch and this is adjusted by taking up the U-loops. This also reactivates the spring. If the loops carrying the spring are distal to the U-loops, the arch is adjusted as usual and the spring re-activated by reducing its curvature.

ADVANTAGES

This is a robust spring which has been used routinely in the orthodontic clinic in Carlisle for one year, with good results. As the loops are formed from round wire the spring is exceptionally free-sliding at its free end, and friction is negligible. Should the spring break it is easily replaced. Soldering or spot-welding, with consequent weakening of the arch and spring, is not required. The force is readily adjusted and the range of movement is more than adequate. Because the spring is long it produces a symmetrical effect upon the incisor teeth and does not flatten the arch.

A disadvantage is that when used on very proclined incisor teeth the spring tends to move up gingivally. This can be countered by curving the spring incisally so that it rests in the correct position.

In conclusion we would like to acknowledge those authors who first described the principle of the self-straightening spring.

A CASE OF 'CANINEMANSHIP'

T. SMITH, B.D.S., L.D.S. R.C.S.

I SUPPOSE I am only human to feel a bit bucked when attractive young ladies visit my surgery for the first time. I have heard it said that it makes one's day. The present case provided dental complications and risks only!

CASE REPORT

The patient was aged 28 and married with two children. She was concerned because her upper right lateral incisor had, during the past year, started to protrude and become loose. Visual examination showed a canine partly erupted and in contact palatally with the offending tooth (*Fig.* 1). The canine was also rotated through 90°. The dentition was mainly in edge-to-edge occlusion. The supporting tissues of all the teeth seemed to be in very good condition and only a little scaling and polishing was necessary to make them first-class. Several fillings had seen better days but the teeth showed no signs of

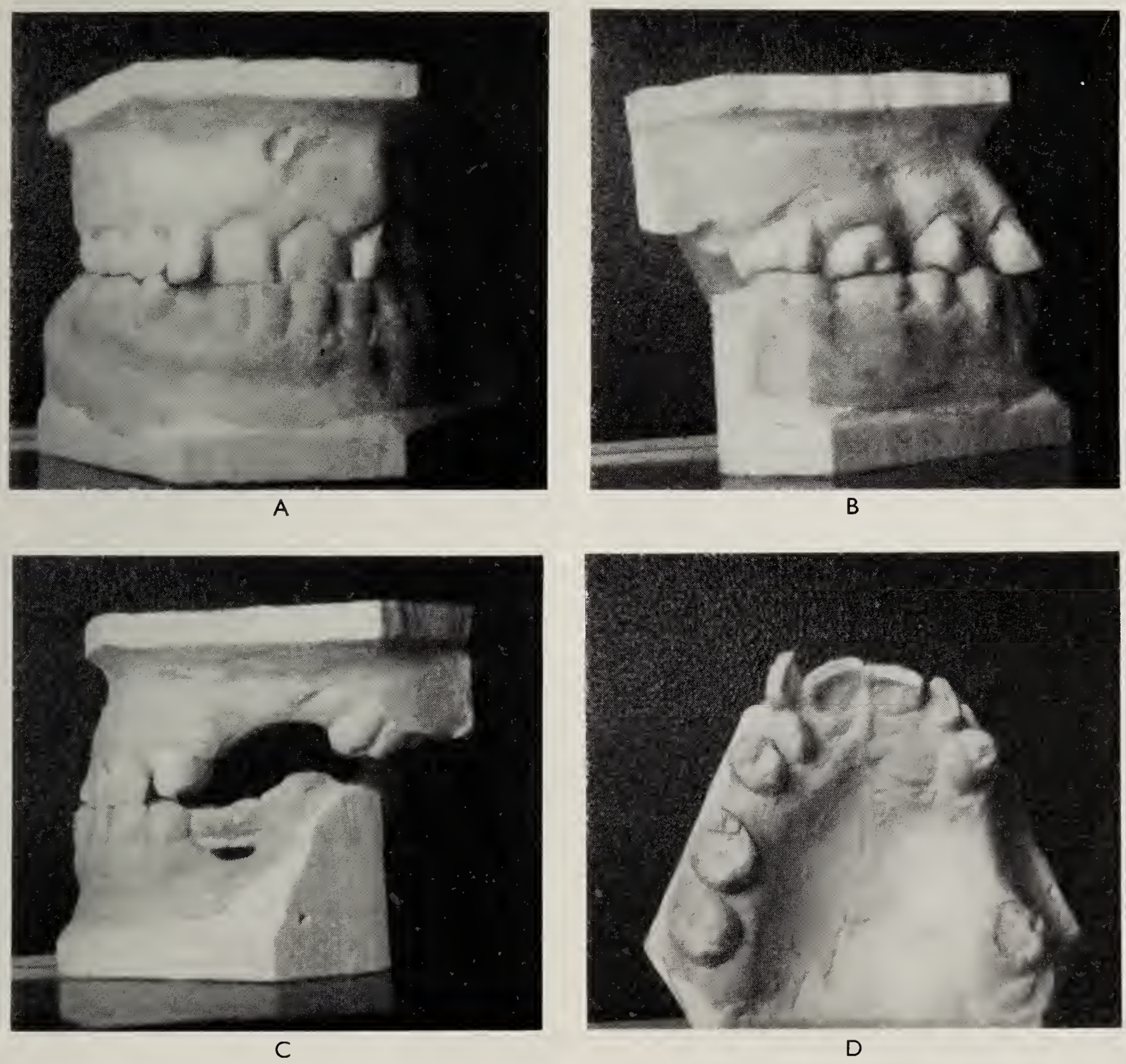
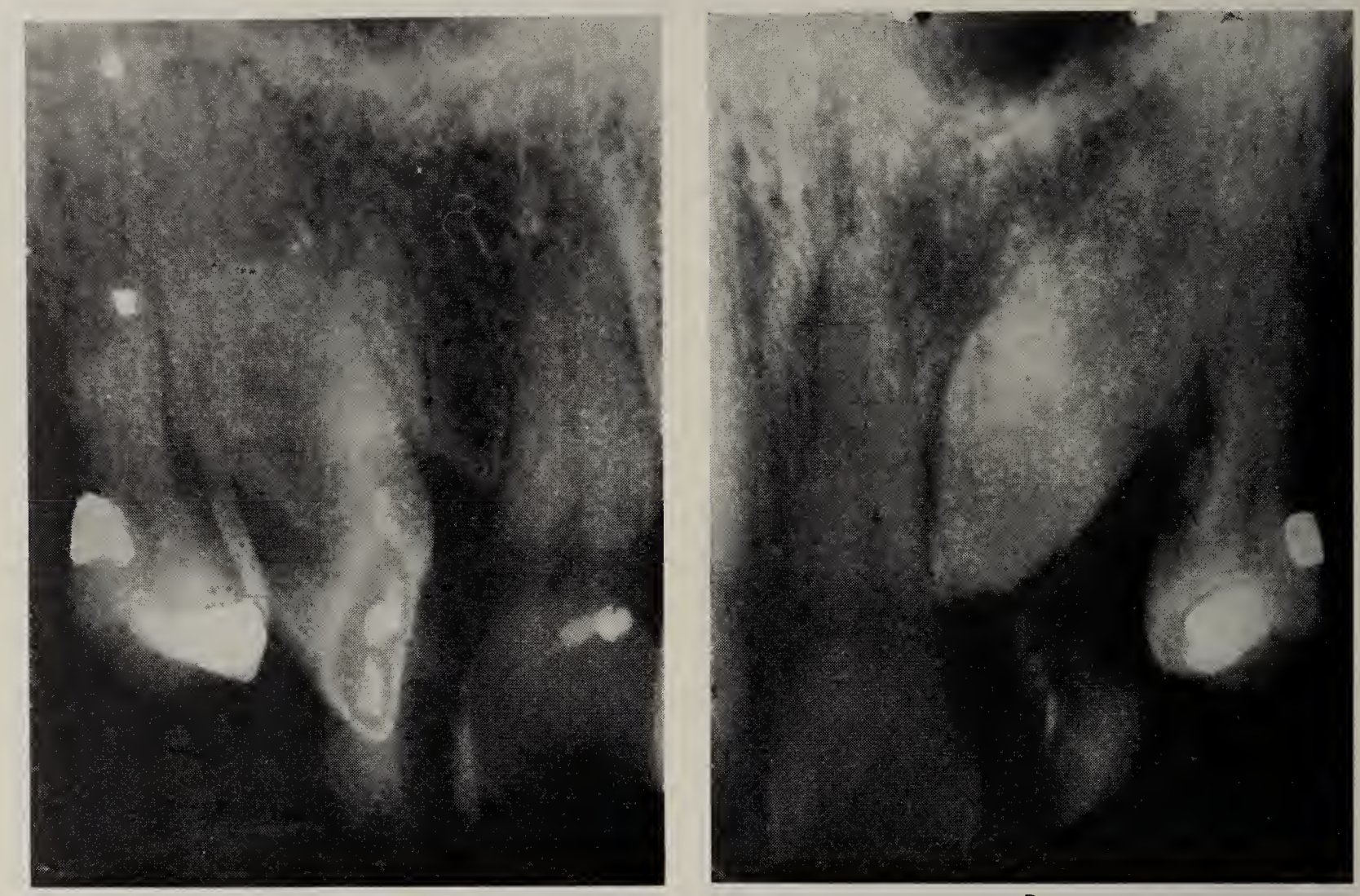


Fig. 1.—Models of the patient before treatment. A, Anterior view. B, C, Lateral views. D, Occlusal view.

Presented at the meeting held on 11 April, 1969.

rapid decay now. The patient said she was medically fit and certainly looked it.

I took study models and radiographed all the teeth. The X-rays showed some loss of attachment round the loose upper right lateral and also revealed the presence of an unerupted and palatally displaced canine on the left side (*Fig.* 2).



A B

Fig. 2.—Intra-oral radiographs. A, $\underline{321|}$. B, $\underline{|123}$.

Fig. 3.—Upper model taken during treatment.

At the next visit, I was able positively to reassure the patient that this one loose tooth was not her imagined harbinger of full dentures. It was then relatively easy to persuade the patient that aesthetically there was little to choose temporarily between the ugly lateral incisor and the canine in its present position with the lateral removed. That the canine could be crowned later to simulate the lateral provided the necessary reassurance for her to have the loose lateral extracted there and then. Luckily for me there was conservative work to do in the lower arch which gave me time to watch and assess the case. During this period, the patient decided she wanted all the gaps in the dentition filling up and so I started by making a fixed-free bridge from $\overline{|7}$ to $\overline{|5}$. Meantime, the canine rapidly erupted forwards into the arch and into an edge-to-edge occlusion (*Fig.* 3). It not unexpectedly chose to snuggle up to the first premolar and keep its distance from the central incisor which did no more than increase the aesthetic problem of crowning a large tooth to simulate a small tooth without leaving a mesial space and evidence of an obvious restoration distally. The answer was to fit a full gold crown to the canine to which was soldered a Steele's backing with a porcelain facing in the position required. The gold crown was also used to carry a spring bridge back to give aesthetic improvement only in the missing upper right second premolar space (*Fig.* 4).

The long-term restoration of the gap in the upper left buccal segment of the arch posed several problems (*Fig.* 1D). For bridgework, the roots of the first premolar seemed rather thin and weak—the marked mesial angulation of the wisdom tooth was also an unfavourable factor. If these teeth failed periodontically or fractured under the load of the bite, I could be faced with the kind of unsupported partial denture

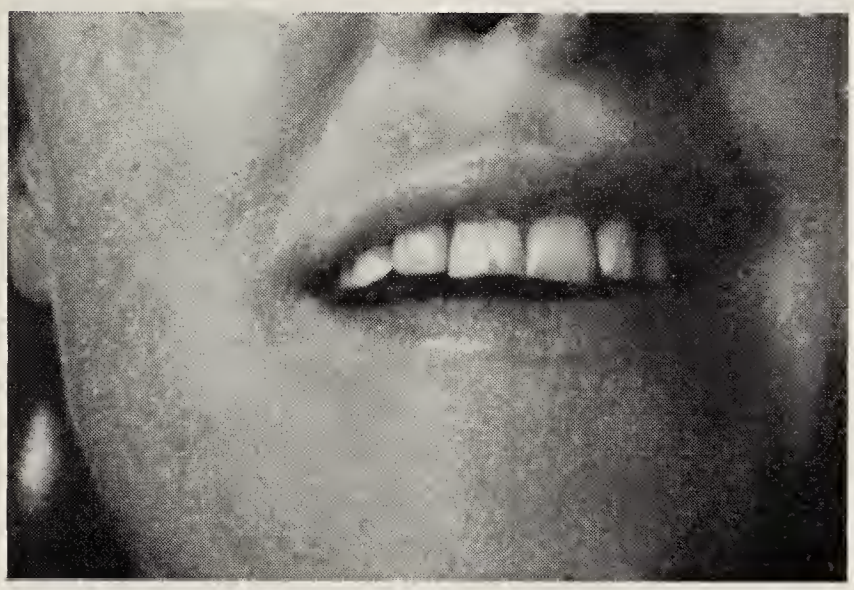
difficulties the patient would least like and I would loathe having to cope with. There was a cross-bite in the molar region to be considered, and also the possibility that the unerupted upper left canine could cause trouble, so bridgework seemed inadvisable.

I had wondered whether the slight space between the upper left central incisor and upper left lateral incisor had any significance but there had been no observable change so far. I decided, however, to uncover the upper left canine and pack it. The canine then started to erupt behind the incisors. A side plate was made to fill the space between the first premolar and wisdom tooth and carry a replacement for the lateral incisor on a high labial bar. A finger spring was inserted in the denture on the palatal side to engage a hook cemented in the canine. The upper left lateral was extracted and the plate inserted during the same visit. As the canine moved into the gap, the back of the acrylic lateral was reduced in advance of it. Eventually, the canine stuck fast short of the occlusion but nearly in the arch. The canine had moved far enough for my needs but to see if I could get just that little bit more, I removed the hook and cut off the buccal bar carrying the lateral incisor from the denture. A small acrylic cap was fitted to the canine just short of the bite, which satisfied the patient aesthetically, and the palatal spring was used just as a guide. This attempt to give the tooth a chance to erupt further virtually on its own failed.

A cast gold pin cap was made for the canine and a gold three-quarter crown for the first premolar. These were soldered together to give a firm anchorage for a Dalbo precision attachment to hold a new side plate.

A

B



C

Fig. 4.—Records at the end of treatment. A, Study model. B, Intra-oral radiographs of $\underline{|43}$. C, Anterior view of the patient's teeth.

The wisdom tooth was left unused except for stabilizing this denture which had fins that could be removed if necessary. A porcelain-bonded-to-gold crown to simulate a lateral incisor was then cemented over the gold cap on the upper left canine to complete the case.

It is difficult for me to say exactly how many times I needed to see the patient for the orthodontic content of my treatment but my records show 42 visits altogether spread over $2\frac{1}{2}$ years with orthodontic treatment mentioned on 18 occasions over a period of 24 months. I have convinced myself that all these visits were necessary despite the suspicion my opening remarks may have aroused that one tends to adjust the appliances of pretty girls more often than strictly necessary.

A LOCAL FIXED APPLIANCE FOR THE CORRECTION OF AN IMPACTED LOWER PERMANENT SECOND MOLAR

D. FRAZER, B.Ch.D., D.Orth., L.D.S. R.C.S.

Orthodontic Department, Charles Clifford Dental Hospital, Sheffield

THE anomaly under consideration in this communication is the impacted lower permanent second molar tooth. This is a condition which has been reported from time to time in the literature, most reports, however, describing the very gross and bizarre types of impaction which are very much the concern of the oral surgeon rather than the orthodontist.

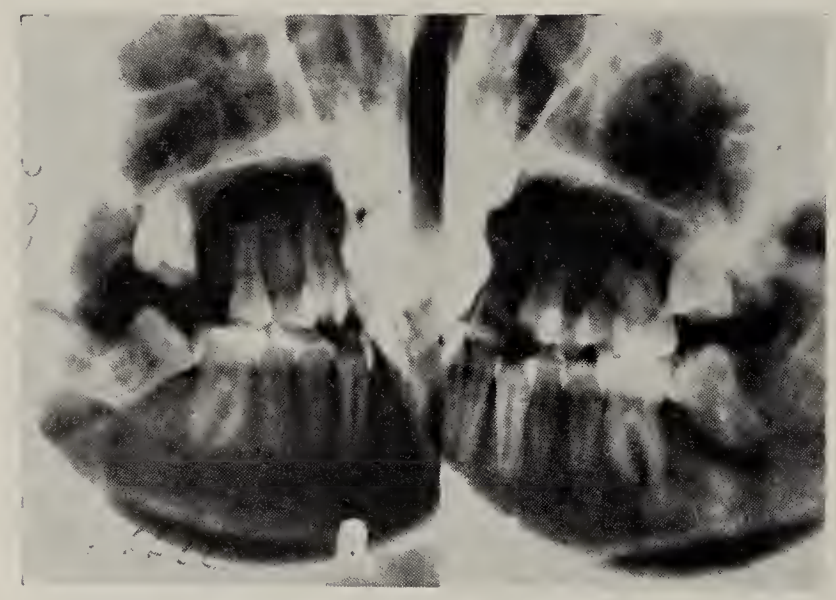


Fig. 1.—Mesio-angular impactions of the lower second molars. No evidence of the third molars. Age 13 yr. 4 mth.

This paper is concerned with the mesio-angular impaction of this tooth as can be seen, for example, on both left and right sides of the radiograph shown in *Fig.* 1. It may be noted that on this film no wisdom teeth are present (age 13 yr. 4 mth.), and it would appear from observation of a number of such cases that the impaction of a mandibular second molar can certainly arise irrespective of the presence or absence of a third molar distal to it. It is by no means a common type of impaction, but, nevertheless, most dental surgeons have had experience of it coming before them and it turns up with sufficient regularity to present a recurring problem in orthodontic practice. The condition was very adequately reported by Munns (1959) who described in detail 6 cases, but wrote, it would seem, a little despairingly about the difficulty in finding an entirely satisfactory solution to the problem.

The possible courses which have been put forward in an attempt to alleviate the situation may be enumerated:—

1. Extract the impacted second molar in the hope that the lower third molar will drift forward and erupt in good position behind the lower first molar. But, as already illustrated in *Fig.* 1, the lower third molar may be absent, or it may be present but itself be in an unsatisfactory position. Munns in his paper mentions the extraction of an impacted lower second molar in a 15-year-old which was followed by impaction of the third molar by the time the patient was 19.

2. Extract the lower third molar immediately behind the impacted second molar in the hope that by removing a possible source of pressure from the distal aspect of the impacted tooth that spontaneous correction of the impaction will occur. Generally speaking, however, this is likely to be simply wishful thinking, as in practice the removal of the third molar seems to make little difference to an already established impaction of the second molar.

3. Extraction of the first permanent molar mesial to the impacted second molar. This will certainly relieve the impaction, but will only result in the already mesially inclined second molar tipping forwards into an even more severely tilted position. This again was reported by Munns as the end-result following extraction of the first molar in these cases.

4. Disimpaction of the lower second permanent molar by means of wire-separating ligatures. The usual method advocated is to pass a 0·5-mm. brass wire under and over the contact points between second and first molars and at intervals to twist up the free ends tightly on the buccal side to effect a separating force between the teeth. However, this again can be a disappointing procedure. In many of these cases it can be virtually impossible to pass the wire under the contact

Presented at the meeting held on 12 April, 1969.

point. In addition, even if the separating wire is passed and tightened successfully and some separation is obtained, the lack of any vertical component of force in this method does not help the depressed mesial aspect of the second molar to rise, and a considerable time may elapse whilst waiting, possibly in vain, for the tooth to erupt further; meanwhile, the patient has a partially loose ligature wire between these teeth for prolonged periods, a situation which is fraught with potential danger. To attempt to increase the degree of separation using a thicker (e.g., 0·7 mm.) wire can be almost impossible due to the difficulty in twisting up a heavy gauge wire between the teeth.

After consideration of the possible approaches to the problem of the established impacted mandibular second molar, it is considered that in those cases where it would not be feasible to extract this tooth with reasonable expectation of the third molar erupting into good position behind the first molar, the most satisfactory solution is to correct the position of the impacted tooth by orthodontic means. A relatively

A

B

C

Fig. 2.—Appliance used in *Case* 2 (Miss J. H.). A, Direct view from buccal side; before insertion of free ends of springs into transverse tube on silver cap. B, Mirror view of lingual side; springs inserted into transverse tube. C, Mirror view; occlusal aspect.

A

B

Fig. 3.—Appliance used in *Case* 1 (Miss V. H.). A, Direct view; springs inserted into short buccal and lingual tubes on silver cap. B, Mirror view; occlusobuccal aspect.

uncomplicated local fixed appliance has been devised to achieve this effectively and expeditiously, and will now be described.

Two versions of the appliance have been used by the writer, the one normally preferred being shown in *Fig.* 2. An orthodontic band is constructed to fit the lower first permanent molar. This will pass mesially between the contact points

A B C

Fig. 4.—*Case* 1 (Miss V. H.). A, Before surgical removal of the unerupted lower right third molar. B, Appliance in situ; the second molar is almost completely disimpacted. C, Two months after removal of appliance.

A B

Fig. 5.—*Case* 1 (Miss V. H.). A, Occlusal aspect. Left model: 11 Oct., 1967, before removal of the unerupted third molar, the second molar is erupted but impacted. Right model: 7 March, 1969, right second molar disimpacted. B, Side view of models as in 5A in occlusion with their corresponding upper models.

of second premolar and first molar in the usual way, but distally the gingival edge of the band will in most cases need to be above the contact points of first and second molars which, because of the impaction, will almost certainly be too tight to be traversed by the band material. An alginate impression is taken of the lower teeth with the band in situ on the first molar and the band seated in the impression following its removal from the mouth so that it reappears accurately placed on the cast model; if desired a thin film of wax can be added to the inner surface of the band prior to casting, which facilitates its later removal from the stone model. Plain McKeag locks are welded to both buccal and lingual surfaces of the band into which will be slotted corresponding buccal and lingual 0·45-mm. springs. The latter are shaped at their mesial ends into a Watkin ' loop and tube ' form which will permit both secure locking and a simple means of removal for spring adjustment when the appliance is in the mouth. On the same stone model a wax pattern is formed to silver cap. Into the open ends of the tubing will be slotted the free distal ends of the buccal and lingual springs which have been bent inwards at right-angles so that springs and silver cap are united by a freely-rotating joint.

To assemble the completed appliance in the mouth the first molar band may be cemented as usual with oxyphosphate or silicophosphate cement, but the silver cap should be cemented to the second molar with the most adhesive cement at one's disposal (the writer used Ames black copper cement) in view of its inherent lack of retention form. The buccal and lingual springs are equally adjusted so that when secured into the McKeag locks on the first molar band their free distal ends lie passively about 2 mm. above and behind the transverse tube on the silver cap (*Fig.* 2A). It is then a simple matter to slot the spring ends into the transverse tube (*Fig.* 2B, C), so activating the appliance to provide an upwards and backwards force transmitted via the silver cap and cement to the mesio-occlusal aspect of the impacted second molar.

It will be appreciated that the silver cap on the second molar should be as thin as possible occlusally, but it is almost inevitable that some slight degree of occlusal interference will occur at its disto-occlusal end when first fitted. In practice this is found to be accepted by the patient and to have disappeared within the first week by spontaneous occlusal adjustment between the second molar and the opposing maxillary tooth. Nevertheless, the situation can exist when there is insufficient occlusal clearance over the mesio-occlusal aspect of the second molar to tolerate the presence of the soldered transverse tubing without seriously interfering with orthodontic movement of the tooth. It is in such a case that the alternative version of the appliance can be used (*Fig.* 3). This is basically as already described, but instead of a length of 0·5-mm. tubing placed transversely on the mesio-occlusal aspect of the silver cap a 2-mm. length of the same tubing is soldered mesio-buccally and mesio-lingually. The free ends of the springs are modified accordingly, but in this arrangement they are unable to rotate in the tubing and the insertion and action of the springs are decidedly less flexible.

A B

Fig. 6.—*Case* 2 (Miss J. H.). A, Impacted lower right second molar before treatment. B, Three weeks after removal of the appliance.

A B

Fig. 7.—*Case* 2 (Miss J. H.). A, Occlusal aspect. Left model: 3 Oct., 1968 prior to fitting silver cap seen in *Fig.* 2 on the impacted second molar. Right model: 4 March, 1969. Appliance removed following disimpaction of the second molar. B, Side view of models as in *Fig.* 7A in occlusion with their corresponding upper models.

CASE REPORTS

Case 1 (*Miss V. H.*)

In March, 1968, at the age of 14 yr. 4 mth. this patient had her unerupted right lower third molar (*Fig.* 4A) surgically removed. Removal of this mal-positioned third molar was certainly indicated in this case and it was hoped that following its removal, the right second molar which itself presented a mesio-oblique impaction would correct its position spontaneously. After several months, however, the right second molar was still impacted and the appliance shown in *Fig.* 3 was fitted. The springs were first activated on 28 Oct., 1968, and by 6 Dec. (i.e., less than 6 weeks later) the tooth was apparently almost disimpacted. A radiograph was taken at that date (*Fig.* 4B) and photographs were taken showing the appliance in the mouth (*Fig.* 3). On 8 Jan., 1969, the appliance was dismantled, and on 7 March (i.e., 2 months after removal of the springs) a further radiograph (*Fig.* 4C) and impressions were taken for study models. The latter are shown side by side with original models of the case in *Fig.* 5).

Case 2 (*Miss J. H.*)

In July 1968, at the age of 16 yr. 11 mth. this patient was referred for orthodontic treatment to correct her impacted right lower second molar. A radiograph was taken (*Fig.* 6A), the appliance cemented on 22 Aug., 1968, and its springs activated on 30 Aug. The silver cap on the right lower second molar in this case had been cast covering only the central part of the occlusal surface without extending to the full extent of the visible periphery of the tooth. As a result of deficient retention the silver cap became detached and was reported lost (extra-orally) by the patient when she next attended on 3 Oct. Little progress was observable on that date at which time impressions were taken from which study models were made. A

new and more adequate silver cap (*Fig.* 2) was constructed and the appliance re-cemented and activated on 31 Oct. On 4 March, 1969, the right second molar was clinically disimpacted, the appliance dismantled, and impressions taken for study models. The latter are shown side by side with the models of 3 Oct., 1968, (*Fig.* 7). On 25 March, 1969, a further radiograph (*Fig.* 6B) was taken showing the right second molar in a satisfactory but, in fact, very slightly relapsed position compared with its position when the appliance was removed. It will be noted that an unerupted third molar has been present throughout in this case, but this did not inhibit in any way the action of the appliance. This third molar might well be removed in due course.

SUMMARY

The possible courses which might be adopted in the treatment of the mesio-angular impaction of a mandibular permanent second molar are discussed and compared. A local fixed appliance is described which has been used effectively in the orthodontic correction of such a malposition.

Acknowledgements

I wish to acknowledge the inspiration and guidance of Mr. J. H. Gardiner, Head of the Orthodontic Department, Charles Clifford Dental Hospital, Sheffield, in the designing of the appliances, and express my thanks to Mr. R. Cousins, Photographic Department, Charles Clifford Dental Hospital, for his preparation of the photographic material.

REFERENCE

MUNNS, D. (1959), *Trans. Br. Soc. Study Orthodont.* 23.

REPORTS OF MEETINGS

ORDINARY MEETING, 14 October

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 14 October, 1968, at 6.30 p.m., with the President, Mr T. Jason Wood, in the Chair.

The PRESIDENT announced to members the deaths of Mr. A. R. Fawcett and Mr. H. K. Titford.

Minutes

The Minutes of the Diamond Jubilee Meeting held on 10 and 11 May, 1968, were read by the HON. SECRETARY (Mr. M. S. E. Gould) and signed as a correct record.

Apologies for Absence

Apologies for absence were received from Mr. C. P. Adams, Professor C. F. Ballard, Mr. T. D. Foster, Mr. S. Haynes, Dr. W. Russell Logan, Mr. J. C. Stephenson, and Mr. P. I. Townend.

Introduction to the President

Mr. D. A. Roberts was introduced to the President and signed the Obligation Book.

Candidates for Election

The following candidates for election to Ordinary Membership were elected *en bloc* by show of hands:—

Ordinary Membership

Miss S. D. Farrant, B.D.S.(U. Lond.), F.D.S., D.Orth. R.C.S.(Eng.), 39 Rutland Gate, London, S.W.7.

Mr. P. S. Bernard, B.D.S.(U. Lond.), L.D.S. R.C.S.(Eng.), 28 Park Avenue North, Hornsey, London, N.8.

Mr. P. T. Burgess, B.D.S.(U. Sydney), ' Delgang ', Esher Place Avenue, Esher, Surrey.

Mr. T. I. McCartney, B.D.S., L.D.S.(Q.U. Belfast), D.D.O. R.C.P.S.(Glasg.), 172 Upper Newtownards Road, Belfast 4, N. Ireland.

Mrs. B. A. Maudsley, B.D.S.(U. Lond.), Heathend House, Windsor Road, Ascot, Berks.

Mr. D. E. Robertson, B.D.Sc.(U. Queensland), D.Orth. R.C.S.(Eng.), ' Wheatcroft ', Eve's Corner, Maldon Road, Danbury, Chelmsford, Essex.

Mr. C. D. Stephens, B.D.S.(U. Lond.), L.D.S. D.Orth., R.C.S.(Eng.), Dental Department for Children, Guy's Hospital, London, S.E.1.

Announcements

The President announced that Sir Kenneth Adamson, of Melbourne, Australia, a Corresponding Member of the Society, had been created a Knight Bachelor by the Queen in the Birthday Honours for July 1968.

The President then announced that the Netherlands Orthodontic Society had presented an inscribed gavel to the Society, and that Dr. Roger O'Meyer had presented a medallion, bearing the head of Pierre Fauchard, both gifts to commemorate the Diamond Jubilee of the Society.

The President welcomed any visitors who might be present and invited them to regard themselves as members for the evening and to take part in any discussion if they so wished. He then delivered his Presidential Address entitled: '*Aesthetics and Orthodontics*'.

Following discussion of the paper, a vote of thanks was proposed to the President by Professor W. J. Tulley and passed by acclamation.

ORDINARY MEETING, 11 November

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 11 November, 1968, at 6.30 p.m., with the President, Mr. T. Jason Wood, in the Chair.

Minutes

The Minutes of the Ordinary Meeting held on Monday, 14 October, 1968, were read by the HON. SECRETARY and signed as a correct record.

Apologies for Absence

Apologies for absence were received from Messrs. C. P. Adams, J. S. Beresford, T. D. Foster, and J. P. Moss.

Candidates for Election

The following candidates for election were elected *en bloc* by show of hands:—

Ordinary Membership

Mr. M. L. Frazer, B.D.S.(U. Lond.), 7 The Green, Twickenham, Middlesex.

Mr. P. F. B. McDonogh, B.D.S.(N.U. Ireland), ' The Sheiling ', 14 Woodcote Park Avenue, Purley, Surrey.

Mr. D. C. Rule, B.D.S.(U. Birm.), F.D.S., D.Orth. R.C.S.(Eng.), Holly House, Camden Park, Tunbridge Wells, Kent.

Corresponding Membership

Mr. R. G. Melville, B.D.S.(Rand), F.D.S., D.Orth. R.C.S.(Eng.), 503 Medipark Hertzog Boulevard, Cape Town, South Africa.

The PRESIDENT then welcomed visitors and introduced Mr. J. R. Halden, and invited him to deliver his paper: '*Some Aspects of Advanced Treatment*'.

ORDINARY MEETING, 9 December

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 9 December, 1968, at 6.30 p.m. with Mr. T. Jason Wood, President, in the Chair.

Minutes

The HON SECRETARY (Mr. M. S. E. Gould) read the Minutes of the Ordinary Meeting held on 11 November, 1968, and these were confirmed and signed as a correct record.

Introduction to the President

Mr. W. J. McK. Barrie was introduced to the President and signed the Obligation Book.

Apologies for Absence

Apologies for absence were received from Mr. C. P. Adams, Mr. A. C. Campbell, Mr. J. D. Hooper, Dr. W. Russell Logan, Mr. J. F. Pilbeam, and Mr. and Mrs. D. Robertson Ritchie.

The PRESIDENT welcomed any visitors and invited Miss J. G. Ritchie to deliver her case report: '*The Movement of Lower Incisors using Modified Crozat Appliances*'. This was followed by case reports by: Mr. H. Lester: '*Treatment of a Case of an Unerupted Central Incisor*', Mr. A. J. Hardingham: '*A Severe Case of Class II, Division 1 Malocclusion with Strongly Adverse Lower Lip Action*', and Mr. H. L. Eirew: '*Dynamic-functional Appliances*'.

ORDINARY MEETING, 13 January

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 13 January, 1969, at 6.30 p.m., with Mr. T. Jason Wood, President, in the Chair.

Minutes

The HON. SECRETARY (Mr. M. S. E. Gould) read the Minutes of the Ordinary Meeting held on Monday, 9 December, 1968, which were confirmed and signed as a correct record.

Apologies for Absence

Apologies for absence were received from Mr. J. S. Beresford, Mr. P. H. Burke, Mr. W. Frankland, and Dr. W. Russell Logan.

Introduction to the President

Mr. C. D. Stephens was introduced to the President and signed the Obligation Book.

Candidates for Election

The following candidates for election to Ordinary Membership were elected *en bloc* by show of hands:—

Mr. S. N. Bhatia, B.D.S.(U. Calcutta), F.D.S., D.Orth. R.C.S.(Eng.), 9 Lovers Walk, Finchley, London, N.3.

Mr. D. Frazer, B.Ch.D., L.D.S.(U. Leeds), L.D.S., D.Orth. R.C.S., 54 Carter Knowle Avenue, Sheffield, S11 9FU.

Mr. P. E. Goodman, B.D.S.(U. Lond.), F.D.S., D.Orth. R.C.S.(Eng.), 59 Fairfield Road, Epping, Essex.

Miss J. C. Harvey, B.D.S.(U. Durh.), D.Orth. R.C.S.(Eng.), 1 The Mount, Heath Street, Hampstead, London, N.W.3.

Mr. R. C. Parkhouse, B.D.S.(U. Lond.), F.D.S., D.Orth. R.C.S.(Eng.), 36 Kindersley Way, Abbotts Langley, Herts.

Mrs. L. R. Read, B.D.S.(U. Lond.), L.D.S., D.Orth. R.C.S.(Eng.), 165 Grand Drive, Raynes Park, London, S.W.20.

Mr. G. S. Taylor, B.D.S.(U. Birm.), 144 St. Denis Road, Selly Oak, Birmingham 29.

The PRESIDENT welcomed visitors and introduced Mr. P. H. Morse and asked him to give his paper entitled: '*The Accurate Assessment of Point A on Lateral Skull Radiographs*'.

This was followed by a paper by Mr. G. P. Rabey entitled: '*Morphanalysis and Orthodontia*'.

ORDINARY MEETING, 10 February

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 10 February, 1969, at 6.30 p.m., with Mr. T. Jason Wood, President, in the Chair.

Minutes

The Minutes of the Meeting held on 13 January, 1969, were read by the Secretary and confirmed and signed as a correct record.

Introductions to the President

The following newly-elected members were introduced to the President and signed the Obligation Book:—

Messrs. D. Frazer and P. E. Goodman, Miss J. C. Harvey.

Elections

The following were elected to Ordinary Membership:—

Mr. F. B. Christie, B.D.S.(U. Lond.), F.D.S., R.C.S.(Edin.), D.Orth. R.C.S.(Eng.), 6 Vanbrugh Hill, Blackheath, London, S.W.3.

Mr. S. J. Zaufal, B.D.S.(Q.U. Belfast), D.Orth. R.C.S.(Eng.), 6 Netherfield Road, Beeson End, Harpenden, Herts.

The PRESIDENT welcomed all visitors present. He drew attention to the fact that nominations

for Council office for 1969/70 were needed very soon.

The PRESIDENT then introduced the first speaker, Mrs. K. W. L. Wraith, who read her paper entitled: '*Methods of Repositioning the Misplaced Canine*'.

Following the discussion of this paper, the PRESIDENT introduced Dr. J. D. Atherton and invited him to read his Chapman Prize Essay: '*Observations on the Growth of the Premaxilla and Maxilla of the Dog when affected by a Unilateral Cleft—an Experiment in Bone Growth*'. The paper was discussed by members, after which the PRESIDENT presented the Chapman Prize to Dr. Atherton.

ORDINARY MEETING, 10 March

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 10 March, 1969, at 6.30 p.m. with Mr. T. Jason Wood, President, in the Chair.

Minutes

The Minutes of the Meeting held on 10 February, 1969, were read by the Secretary and confirmed and signed as a correct record.

Introductions to the President

The following newly-elected members were introduced to the President and signed the Obligation Book:—

Mr. F. B. Christie
Mr. S. J. Zaufal

Candidates for Election

The following candidates were elected *en bloc* by show of hands:—

Ordinary Membership

Mr. A. Becker, B.D.S.(U. Lond.), L.D.S. R.C.S.(Eng.), D.D.O. R.C.P.S.(Glasg.), 6 Howberry Road, Canons Park, Edgware, Middlesex.

Mr. G. H. P. Bolton, B.D.Sc.(U. Queensland), D.Orth. R.C.S.(Eng.), 125 Cannon Lane, Pinner, Middlesex.

Mr. J. D. Coote, B.D.S.(U. Durh.), F.D.S., D.Orth. R.C.S.(Eng.), 28 Brookside, Whitehouse Farm Estate, Witton Gilbut, Co. Durham.

Mr. P. J. T. Grifiths, B.D.S.(U. Lond.), F.D.S., D.Orth. R.C.S.(Eng.), Coombe End Farmhouse, Whitchurch, Reading, Berks.

Miss M. C. Hamilton, F.D.S. R.C.S.(Eng.), Widdrington Hall, Church Road, Edgbaston, Birmingham 15.

Major R. A. Smart, B.D.S.(U. Edin.), F.D.S., D.Orth. R.C.S.(Eng.), Royal Army Medical College, Millbank, London, S.W.1.

Corresponding Membership

Mrs. Lye Thim Loke, B.D.S.(U. Malaya), D.Orth. R.C.S.(Eng.), 65 Kheam Hock Road, Singapore 11.

Mr. M. A. C. Nugent, B.D.S.(U. Queensland), D.Orth. R.C.S.(Eng.), F.A.C.D.S., M.S.(Rochester, N.Y.), Department of Dental Science, The University of Adelaide, Adelaide, S.A. 5001, Australia.

The PRESIDENT welcomed all visitors and made special mention of the presence of Mr. Arthur D. Lewis, the Editor of the *Angle Orthodontist*.

Announcement

The HON SECRETARY reminded members intending to be present at the Country Meeting in Leeds that their reservations should be sent to the Assistant Secretary as soon as possible. He drew members' attention to the Ordinary Meeting in Manchester on 18 March and to the Scientific Meeting on 10 May of the Royal College of Surgeons of England on '*Other Disciplines in Relation to Orthodontics*'.

Mr. C. P. Briggs then read his Short Communication: '*Post-treatment Analysis of Angle's Class II, Division* 1, *and Class II, Division* 2 *Malocclusions in a Pair of Identical Twins*'.

This was followed by a paper by Mr. R. C. Parkhouse: '*A Cephalometric Appraisal of Cases of Angle's Class II, Division* 1 *Malocclusion treated by the Andresen Appliance*'.

ORDINARY MEETING, 18 March

AN ORDINARY MEETING of the Society was held in the Roscoe Building, the University of Manchester, on Tuesday, 18 March, 1969, at 5.30 p.m. with Mr. T. Jason Wood, PRESIDENT, in the Chair. It was preceded by a Demonstration Meeting of the Manchester Orthodontic Study Circle to which members of the Society were invited, which invitation the Society reciprocated.

Apologies for Absence

An apology for his absence was received from Mr. A. C. Campbell.

Minutes

The HON. SECRETARY read the Minutes of the Ordinary Meeting held on Monday, 10 March, 1969, which were confirmed and signed as a correct record.

The PRESIDENT welcomed visitors, and invited Mr. J. H. Gardiner to read the paper by Mr. A. C. Aamodt and himself entitled: '*Some Aspects of Soldering Stainless Steel—A Metallurgical Investigation*'.

This was followed by a paper by Mr. M. S. E. Gould: '*Begging—the Question*'.

RESEARCH MEETING, 10 April

THE RESEARCH MEETING of the Society was held at Bodington Hall, the University of Leeds, at 2.0 p.m. on Thursday, 10 April, 1969. The PRESIDENT, Mr. T. Jason Wood, occupied the

Chair and papers and research reports were presented as follows:—

Papers

2.00 p.m. Mr. P. Vig: '*Cinedots—a New Method of Cineradiographic Analysis*'.

2.30 p.m. Mr. J. Murray: '*Prevalence of Malocclusion in Fifteen-year-old Children from Fluoride and Non-fluoride Communities*'.

3.00 p.m. Mr. D. D. Di Biase: '*Midline Supernumeraries and Eruption of the Maxillary Central Incisor*'.

Research Reports

4.00 p.m. Mr. E. M. Harkness: '*Prevalence of Malocclusion in a Random Sample of Twelve-year-old Cardiff schoolgirls*'.

4.15 p.m. Messrs. W. A. B. Brown, E. M. Harkness and A. J. P. Cousins: '*An Assessment of the Need for Orthodontic Treatment in a Random Sample of Twelve-year-old Cardiff schoolgirls*'.

4.30 p.m. Miss Rosaline Smallcombe: '*An Analysis of Familial Characteristics in the Human Dentition*'.

4.45 p.m. Mr. J. F. Gravely: '*A Cross-sectional Study of the Prevalence of Molar and Canine Crossbites in the Deciduous and Mixed Dentition*'.

ANNUAL GENERAL MEETING, 11 April

THE ANNUAL GENERAL MEETING of the Society was held in Bodington Hall, University of Leeds, on Friday, 11 April, 1969, at 9 a.m., with the PRESIDENT, Mr. T. Jason Wood, in the Chair.

The HON. SECRETARY (Mr. M. S. E. Gould) read apologies for absence from Mrs. M. E. H. Davis, Dr. W. Russell Logan, Messrs. J. S. Beresford, P. H. Burke, and T. D. Foster.

He then read a telegram from the Yorkshire Branch of the British Dental Association sending best wishes for a successful meeting.

The Secretary then read the Minutes of the last Annual General Meeting held in London on Friday, 10 May, 1968. The Minutes were approved and signed as a correct record.

Election of Officers and Councillors

The PRESIDENT said that the agenda set out the nominations which had been put forward by the Council. He suggested that they be elected *en bloc*, if members were agreeable. (Agreed.)

He therefore proposed that the Officers as set out in the agenda be elected for the following year:—

President:	Mr. J. H. Gardiner
Immediate Past President:	Mr. T. Jason Wood
President Elect:	Professor B. C. Leighton
Senior Vice President:	Mr J. F. Pilbeam
Vice President	Dr. J. R. E. Mills
Treasurer:	Mr. J. S. Rose
Secretary:	Mr. M. S. E. Gould
Assistant Secretary:	Miss J. G. Ritchie
Editor:	Dr. J. D. Atherton
Curator:	Mr. R. D. Howard
Librarian:	Mr. A. C. Campbell

The proposal was carried.

The PRESIDENT said that three Councillors, Mr. C. P. Adams, Mr. W. Frankland, and Mr. R. W. Willcocks, had not yet completed their term, and he proposed that those three be re-elected *en bloc*.

The proposal was carried.

The following nominations for the remaining two Councillors had been received:—

Mr. D. T. Bennett, Mr. R. T. Broadway, Mr. W. A. B. Brown, Mr. J. P. Moss, Dr. T. H. M. Wynn.

The following were elected: Mr. R. T. Broadway, and Mr. W. A. B. Brown.

Election of Two Auditors

Mr. J. S. Rose proposed that Mr. P. H. Burke and Mr. A. J. Walpole Day be invited to continue as Auditors. Mr. R. W. Willcocks seconded.

There were no other nominations and the proposal was carried.

Hon. Treasurer's Report

Mr. J. S. ROSE said that this was the second full year on the new calendar year basis, so that the comparative figures were of more use than those shown in the 1967 accounts. There had been an excess of income over expenditure for the year under review of £475. 17s. 10d., and this reflected the results of the new rates of subscription. The sales of TRANSACTIONS had fallen by £30 from the previous unusually high figure, and Mr. Rose expressed his appreciation of the Librarian's work in this connexion. There was an increase of £50 in the gross dividend yield.

On the expenditure side, the Jubilee Meeting had cost somewhat more than normal, but the previous year's figure was unusually low because of the generosity of Bristol University. There were reductions in the cost of refreshments and reporting. Bank charges had been increased, and this was accounted for by the fact that they were now transferring their investments into the name of the Westminster Bank nominees.

During the year the Society's holding in National Savings Certificates was encashed, and the proceeds were invested in Liverpool Corporation stock. The right of conversion was taken with regard to both the Baker Parkins loan stock and the Boulton and Paul loan stock.

Mr. Rose appealed to all those who had not taken out a subscription to the *Dental Practitioner* to do so as early as possible. Members were reminded that the Society had an arrangement with John Wright & Sons Ltd., who printed both the *Dental Practitioner* and their TRANSACTIONS

to guarantee them a minimum of two hundred subscriptions from the Society, and any subscriptions below the number of two hundred were charged back to the Society's accounts.

The reception of the Report was proposed by Mr. Rose and seconded by Mr. R. W. Willcocks. The Report was adopted on the proposal of the President.

Hon. Secretary's Report

Mr. M. S. E. GOULD said that it was just over a year since Mr. Campbell had handed over the duties of Secretary to him, and he thanked him for all the help and advice which he had always been ready to give during that time.

During the past year, there had been six Ordinary Meetings at Manson House with an average attendance of 87—slightly fewer than had been usual in recent years. However, those figures had been taken from the attendance book, and it had been clear on several occasions that some members had not recorded their presence in it. It would be helpful if members would remember to sign in so that assessments of facilities required subsequently could be made.

The attendance at the Jubilee Meeting in London last May had been a record 202 members and visitors.

In pursuance of the policy of holding meetings away from London, an additional Ordinary Meeting was held in Manchester on 18 March. In spite of most unfavourable weather, 41 members and visitors were present, and he thanked Mr. Gardiner, Mr. Robertson, and the members of the Manchester and District Orthodontic Study Group who had done so much of the secretarial work and organization. It was hoped that further additional meetings of that kind could be organized, and it was expected that a meeting in Scotland would be arranged during the forthcoming year.

The Society's membership had continued to increase and had now passed the 600 mark. They had lost 17 members, 2 by death and 15 by resignation, but they had been joined by 25 new Ordinary Members and 3 new Corresponding Members. The net increase of 13 over the year raised the total to 612.

The Council fully recognized and were anxious that the Society should evolve to meet the requirements of the enlarging membership, and they were making efforts to that end. In the past these efforts had included the change in the times of meetings and the additional regional meetings. This year, changes in the bye-laws had been proposed. The Council welcomed constructive suggestions from members concerning further developments.

The Council was anxious to receive offers of material for inclusion in the future programme.

The reception of the Report was proposed by Mr. Gould and seconded by Miss J. G. Ritchie. The Report was adopted on the proposal of the President.

Hon. Editor's Report

Dr. J. R. E. MILLS said that the year which was now drawing to a close had not seen any major changes in the Society's publications. The TRANSACTIONS for 1967/68 had completed publication in the *Dental Practitioner* in February, and the bound copies of those TRANSACTIONS should be in members' hands shortly.

The Council had made a number of policy decisions. First, it had been decided that in future the bound volumes of TRANSACTIONS should be consecutively numbered so that the 1967/68 TRANSACTIONS would become Volume 54. This was intended to prevent confusion which might otherwise arise because of the TRANSACTIONS spanning two years.

Secondly, the Council had decided to conform with the policy of the Royal Society's Conference of Editors, and in future to ask contributors to use only metric units in papers read to the Society. The only exception to that was that angular measurements could continue to be given in degrees rather than the little-used radians. Apart from conforming to general scientific practice, this would have the advantage of eliminating a rather sloppy mixture of metric and Imperial units which had sometimes occurred in the past.

The third decision had arisen from the vigilance of the former Secretary, Mr. A. C. Campbell, who had drawn attention to a resolution of the Council passed on 6 November, 1933, which read: 'That papers dealing with investigations involving intricate calculations or other matters which render them unsuitable for reading (before the Society) but which are considered worthy of acceptance for publication (by the Society) should be taken as read and be printed in the Transactions of the Society'. The present Council felt that there were a few outstanding papers which, because of their statistical nature, were less suitable for verbal presentation, but which they would wish to have in their TRANSACTIONS. It seemed that the original resolution had never been implemented, but the Council felt that this should be done occasionally, and it was hoped to publish the first such paper in the current TRANSACTIONS.

This was, of course, merely following the example of many other learned societies, and Dr. Mills believed that in the future they might also at times find it convenient to have an occasional evening of papers of a general nature or of case reports which they would not publish in full in the TRANSACTIONS. However, such a decision would be made by others, since this was his last report as the Society's Honorary Editor. His successor, Dr. J. D. Atherton would be pleased to receive offers of papers for presentation during

the coming winter session, but as soon as the publication of the TRANSACTIONS for this Country Meeting was completed, Dr. Mills said his duties would end.

He thanked the Society for allowing him the privilege of being the Editor for the past eight years. He also thanked all those who had made his task possible: the members of successive editorial committees and councils for their unfailing support; the reporters who had made the discussions of the papers intelligible; their publishers, Messrs. John Wright & Sons Ltd., who had done much of his work for him; and many others. In particular, he thanked his secretary, Miss J. Jeffery, whose help throughout the period had been invaluable.

Dr. Mills hoped that he would hand over the Society's editorial business to Dr. Atherton in as good shape as he had received it eight years ago from Professor Tulley.

The reception of the Report was proposed by Dr. Mills and seconded by Mr. A. C. Campbell. The report was adopted on the President's proposal.

The PRESIDENT congratulated Dr. Mills on entering the ' Presidential pipeline ' and proposed a vote of thanks to him for his work as Editor over the preceding eight years. This was carried by acclamation.

Hon. Curator's Report

Mr. R. D. Howard said that the last year had been a quiet one for the Society's museum. No material had been submitted by members, and the only additions to the collection had been made by the Curator. The museum still required early orthodontic instruments and appliances, and if any members had such material, the Society's museum would be very grateful.

The reception of the Report was proposed by Mr. Howard and seconded by Miss J. G. Ritchie. The PRESIDENT proposed its adoption and this was carried.

Hon. Librarian's Report

Mr. A. C. Campbell said that, following the good offices of his predecessor, Miss Ritchie, books, bound volumes of the Society's TRANSACTIONS and other periodicals were now housed in the library of the British Dental Association at 64 Wimpole Street, London, W.1.

The Society maintained stocks of some past issues of its TRANSACTIONS for which requests were received from many parts of the world. Some members had kindly made available past issues, and these were gratefully accepted. He particularly thanked Dr. L. M. Clinch for her donation of a complete set of TRANSACTIONS.

Members would have seen a notice on the agenda sheet for the meeting regarding the Society's need of some past issues of the *Angle Orthodontist* in order to complete volumes prior to binding. Mr. Campbell said he would be very glad to receive these or any past volumes of the TRANSACTIONS.

He thanked Mrs. Oates for her continuous work in managing the despatch and sale of TRANSACTIONS to institutions and persons outside the Society.

The reception of the Report was proposed by Mr. Campbell and seconded by Mr. R. W. Willcocks. The Report was adopted on the proposition of the PRESIDENT.

Amendments to Bye-laws

The amendments to the Bye-Laws as set out in the agenda were put to the meeting, and carried.

Any Other Business

Mr. W. A. B. Brown said that he had already written to the President on the matter which he now wanted to raise, and his purpose in mentioning it now was not to develop a discussion at the present meeting but so that attention could be given to it in the future.

In the first place, Mr. Brown hoped that in the future the B.S.S.O. Country Meeting would not clash with the meeting of the International Association for Dental Research to which some people had already gone.

Secondly, the B.S.S.O. was becoming more regional in its nature. With the development of new study groups, it would be as well to consider whether it would be advisable to include these study groups in the net of the B.S.S.O. with a view to trying to get a group idea, a British idea, of what orthodontics was about.

Thirdly, Mr. Brown pointed out that there existed the British Association of Orthodontists, the Consultant Orthodontists Group, the Orthodontic Teachers Group, and other organizations, and this meant that there were five or six meetings each year which people could attend. This seemed to be a little out of proportion when one considered that there were only a few full-time orthodontists in this country.

Mr. Brown suggested that, during the coming year, some thought could be given to resolving some of these problems.

The PRESIDENT thanked Mr. Brown for his comments which opened up a tremendous area for discussion. The Council had already taken note of his remarks and would act accordingly. If anybody had any further points to make on these subjects, he hoped they would communicate with the Council very quickly.

There being no further business, the meeting terminated.

COUNTRY MEETING, 11 and 12 April

The eleventh COUNTY MEETING opened in Bodington Hall, Leeds University, at 9.30 a.m. on 11 April, with the PRESIDENT, Mr. T. Jason Wood, in the chair.

The SECRETARY read the Minutes of the Ordinary Meeting held in Manchester on 18 March. These were confirmed and signed as a correct record.

Introduction to the President

Two new members, Mr. J. D. Coote, and Mr. G. S. Taylor, were introduced to the President and signed the Obligation Book.

The Programme of the Meeting was then presented, as follows:—

Friday, 11 *April*

9.30 a.m. 23rd Northcroft Memorial Lecture: Mr. G. C. Dickson: '*The Natural History of Malocclusion*'.

10.30 a.m. Coffee.

11.00 a.m. Paper: Messrs. A. J. P. Cousins, W. A. B. Brown, and E. M. Harkness: '*An Investigation into the Effect of the Maxillary Bite Plate on the Height of the Lower Incisor Teeth*'.

11.45 a.m. Case Report: Mr. T. Smith: '*A Case of Caninemanship*'.

2.0 p.m. Paper: Mr. F. J. MacCauley: '*Ectopic Incisors—Some Case Reports*'.

2.30 p.m. Case Reports: Mr. J. S. Rose: (1) '*Treatment of Inverted Unerupted Central Incisors.* (2) *Treatment following Traumatic Loss of Upper Central Incisors*'.

3.15 p.m. Tea.

3.45 p.m. Table Demonstrations.

Mr. T. P. Bass and Mr. S. I. M. Robinson: '*Forces Involved in Incisor Retraction*'.

Mr. D. Frazer: '*Construction of an Inexpensive Illuminated Tracing Table*'.

Mr. D. G. Gould: '*A Direct/Indirect Method of Making Orthodontic Bands*'.

Mr. J. H. Martin and Mr. J. D. McEwen: '*Some Cases showing Unusual Incisor Problems*'.

Mr. A. H. K. Price: '*A Portable Audio-visual Teaching Aid*'.

Mr. P. I. Townend: '*A Modified Self-straightening Spring for Retroclination of Upper Incisors*'.

The following demonstrations were open for inspection throughout the meeting:—

Messrs. J. F. Gravely, P. Davidson and S. Pearson: '*Orthodontics Related to Restorative Dentistry*'.

Mr. R. D. Howard: '*Megadont Incisors*'.

7.00 p.m. Reception by Leeds University at Bodington Hall.

7.30 p.m. Dinner Dance at Bodington Hall.

Saturday, 12 *April*

9.30 a.m. Paper: Dr. J. R. E. Mills: *Use of the Watkin Appliance*'.

10.15 a.m. Short Communication: Mr. D. Frazer: '*A Local Fixed Appliance for Correction of an Impacted Lower Permanent Second Molar*'.

10.45 a.m. Coffee.

11.15 a.m. Film: Professor W. J. Tulley: '*Orthodontics in Latin America*'.

Closure of the Meeting and Introduction of the New President

The PRESIDENT said it was now time for him to make his bow. It had been a wonderful experience being President. At times the adrenaline flow had been rather high, but it had been worth it. He thanked the Council for being so co-operative throughout the year. He particularly thanked Stephen Gould and Jeffrey Rose for helping him at the meetings, and for putting him back on the rostrum when he fell off—by word and deed.

He also hoped they would show their appreciation of the way Mr. Harden from the Leeds Dental Hospital had helped them. He had put in a great deal of time before the conference, and he had done the necessary work extremely well.

Mr. Jason Wood then introduced the new President. He had known Jim Gardiner since he had been a lad. He was a tremendously enthusiastic orthodontist. 'Jim lives and breathes orthodontics', went on Mr. Jason Wood. 'If he was ever so involved that he had to take a breathalyser test, the crystals wouldn't turn green, but if you broke the phial afterwards you would see running through it the word orthodontics—as in Blackpool rock'.

Mr. Gardiner was the backbone, the mainspring, and the President of that very successful and flourishing organization, the Sheffield Orthodontic Study Circle. He had also been very successful in organizing post-graduate courses. He was a great teacher and a terrific organizer; when he gave his mind to anything, nothing was too much trouble and no detail too small. They have a very good man for their President for the next year.

The retiring President then invested Mr. J. H. Gardiner with the Jewel of Office.

A vote of thanks to the retiring President was proposed by Mr. C. D. Parker and carried with acclamation.

The President (Mr. J. H. Gardiner) then closed the meeting with the announcement that the next meeting would be at Manson House on Monday, 13 October, 1969.

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

Balance Sheet and Income and Expenditure Sheet

FOR THE

YEAR ENDED 31 DECEMBER, 1968

COLE, DICKIN & HILLS,
CHARTERED ACCOUNTANTS, AUDITORS
18, Essex Street, Strand, London, W.C.2

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

INCOME AND EXPENDITURE ACCOUNT for the Year ended 31st December, 1968

31.12.1967 £	£		£ s. d.	£ s. d.
11		To *Museum Rent*		1 15 0
		„ *Meeting Expenses:—*		
	54	Hire of Hall	54 0 0	
	136	Refreshments	89 8 0	
	168	Reporting	102 15 6	
	18	Lanterns and Films	10 10 0	
	21	Jubilee Meeting (Net).. ..	139 14 1	
	53	Northcroft Memorial Lecture	52 10 0	
450	—	Sundry Items	22 10 0	471 7 7
26		„ *Chapman Prize* (1968)		26 5 0
		„ *Printing*		
	1150	Publications	1362 3 0	
	270	General Printing and Stationery	318 7 1	
1420	—	Binding of Journals	100 13 0	1781 3 1
38		„ *Library and Journals*		31 10 0
123		„ *Postage*		189 12 3
200		„ *Secretarial Assistance*		200 0 0
7		„ *Honoraria*		26 5 0
73		„ *Accountancy*	73 10 0	
		„ *Accountancy Previous year* ..	15 15 0	89 5 0
5		„ *Insurance*		4 17 9
8		„ *Sundry Expenses*		16 18 6
28		„ *Depreciation of Furniture and Equipment*		20 15 0
1		„ *Repairs*		5 5 0
9		„ *Bank Charges*		20 17 7
406		„ *Excess of Income over Expenditure for the year*		475 17 10
£2805				£3361 14 7

31.12.1967 £	£		£ s. d.	£ s. d.
	1825	By *Members' Subscriptions*	2584 15 10	
1828	3	Arrears Collected	18 5 0	2603 0 10
301		„ *Sale of Transactions*		269 15 0
246		„ *Overprovision for Publications in previous year*		— — —
303		„ *Interest and Dividends Received and Accrued*		338 8 3
127		„ *Income Tax Recoverable*.. ..		150 10 6
£2805				£3361 14 7

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

BALANCE SHEET as at 31st December, 1968

31.12.1967 £	£		£ s. d.	£ s. d.
		Accumulated Fund:—		
	5364	Balance at 1st January, 1968 ..	5769 15 2	
5770	406	Excess of Income over Expenditure for the year	475 17 10	6245 13 0
		Creditors and Reserves:—		
	2054	Publications Printing Reserves ..	1300 0 0	
	308	General Creditors and Accrued Charges	214 16 6	
	115	Subscriptions in Advance ..	9 10 0	
2503	26	Petty Cash Accounts	7 6 11	1531 13 5
£8273				£7777 6 5

P. H. BURKE
A. J. W. DAY } *Hon. Auditors*

J. S. ROSE *Hon. Treasurer*

31.12.1967 £	£		£ s. d.	£ s. d.
		Fixed Assets:—		
	82	Furniture and Equipment Balance at 1st January, 1968	54 0 0	
		Addition during year	1 15 0	
			55 15 0	
54	28	*Less*: Depreciation	20 15 0	35 0 0
		Investments at Cost:—		
	1282	1200 National Savings Certificates	— — —	
	509	500 5¼% Corporation of London 1976/79	508 10 9	
		£1516 Liverpool Corporation 4¾% Redemption Stock 1970/74 ..	1310 5 0	
	151	£150 British Insulated Callenders Cables Ltd. 7% Debenture Stock 1985/90	151 4 0	
	761	£700 Sun Alliance and London Insurance Ltd. 6½% Conv. Loan Stock 1980/85	760 13 7	
	744	£675 Fisons Ltd. 6½% Conv. Loan Stock 1985/90	744 12 0	
	751	£650 Baker Perkins Holdings Ltd. Conv. Loan Stock 1982/85 ..	— — —	
	783	£750 Boulton & Paul Ltd. 7% Conv. Loan Stock 1981/91 ..	— — —	
	502	230 Coats Paton Ltd. £1 Ordinary Shares	502 3 6	
	455	£218 British Insulated Callenders Cables Ltd. Ordinary Stock ..	455 2 5	
	478	£50 Royal Insurance Co. Ltd. Stock	478 10 0	
		£286 Baker Perkins Holdings Ltd. Ordinary Stock	750 19 8	
		450 Boulton & Paul Ltd. Ordinary Shares ..	782 16 9	
6416		759 Boulton & Paul Ltd. 'A' Non-Voting Ordinary		6444 17 8
		(Approximate Market Value at 31.12.1968 £8033)		
220		*Income Tax Recoverable*		244 11 8
28		*Prepayments and Dividends Receivable*		82 12 9
		Cash at Bank:—		
	532	Westminster Bank Ltd.	236 10 3	
	19	P.O.S.B.	19 0 11	
1551	1000	Deposit Account	700 0 0	955 11 2
4		*Cash in Hand*		14 13 2
£8273				£7777 6 5

We have prepared the above Balance Sheet and Accounts from the books, records and information given to us and we certify them to be in accordance therewith. We have verified the investments and cash at Bank.

18, Essex Street, Strand, London, W.C.2.
4th March, 1969

COLE, DICKIN & HILLS
Chartered Accountants

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